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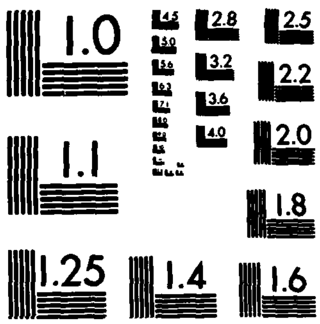

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

FINAL REPORT

Housing and Wood Products Assessment

Submitted To:

Congress of the United States

Office of Technology Assessment

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by

The Environmental Awareness Center
University of Wisconsin-Extension

HOUSING AND WOOD PRODUCTS ASSESSMENT

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Introduction

Projecting future wood needs in the housing industry has many facets: understanding characteristics of present housing stock; projecting regional growth trends; and studying architectural and construction innovations; as well as ascertaining barriers to implementing housing innovation. Many of these areas are in a dramatic state of flux due to changes in growth trends, lifestyles and the economy. The housing industry, thought by many to be impervious to change, is being forced to address these changes. This state of flux makes this a timely report, but also makes quantitative projections difficult. Some changes are pulling the housing industry in different directions, while the affects of others are compounded.

This report attempts to describe the many areas affecting housing needs and to delineate their resultant impact on wood types and amounts needed for future housing.

Housing Characteristics and Housing Production

Recent data from the 1980 Census of Housing reported that there were 88.4 million housing units in the United States, of which 86.8 million were for year-round use and 1.6 million for seasonal and migratory use (U.S. Bureau of the Census, 1982a). The number of occupied housing units or households was 80.4 million of which 51.8 million or 64.4 percent were homeowners (Table A). Single-family housing units accounted for 57.5 million or 66.2 percent of all year-round housing units, while multi-unit accounted for 25.0 million units or 28.8 percent of the total and mobile homes 4.3 million or 5.0 percent. About 44 million or slightly over one-half of these units had 3 or more bedrooms. All but 2.9 million or 3.3 percent had at least one complete bathroom. About 22.4 million units or 25.8 percent were reportedly built from 1970 to March 1980 while 22.7 million or 26.2 percent were built before 1940. Data in Table A from the Annual Housing Survey shows slightly more single-family houses (U.S. Bureau of the Census, 1982b).

Data on housing size is not available from the 1980 Dicennial Cenus, however, a recent survey of residential energy consumption provides for the first time data on square footage of residences (Department of Energy, 1982). It should be noted that floor area reported by the Department of Energy may be somewhat larger than finished floor area reported for new housing construction

Table A.---Characteristics of Housing Inventory, Selected Years 1940-1980
(units in thousands)

Type of Unit	1940	1950	1960	1970	1974[1/]	1977[1/]	1980[1/]	1980
All Housing Units	37,325	45,983	58,326	68,672	77,601	82,420	88,207	88,411
Vacant--seasonal and migratory	740	3,291	1,742	973	1,715	1,704	2,183	1,642
All year-round housing units	36,585	42,692	56,584	67,699	75,886	80,716	86,024	86,769
Occupied Units:	34,855	42,826	53,024	63,445	70,830	75,280	80,072	80,390
Owner occupied	15,196	23,560	32,797	39,886	45,784	48,765	52,516	51,795
Single detached	NA	19,474	28,436	34,397	38,482	41,215	44,332	43,322
Single attached	NA	1,268	1,526	1,113	1,524	1,735	1,993	1,784
2-4 unit	NA	2,369	1,899	2,161	2,065	2,137	2,247	2,256
5 or more	NA	200	258	464	543	642	897	1,385
Mobile home or trailer	NA	250	677	1,752	3,169	3,036	3,041	3,049
Renter Occupied:	19,659	19,266	20,227	23,560	25,046	26,515	27,556	28,595
Single detached	NA	7,194	7,891	7,736	7,110	7,086	7,382	7,508
Single attached[2/]	NA	1,412	1,860	794	1,325	1,156	1,176	1,467
2-4 unit	NA	5,968	5,027	6,218	6,516	7,326	7,468	6,652
5 or more	NA	4,627	5,360	8,491	9,550	9,490	10,801	12,202
Mobile home or trailer	NA	641	90	321	545	657	728	766

1/ Data from AHS survey differs somewhat from 1970 and 1980 Census of Housing because of sampling and procedural differences. Therefore, data from 1970 and 1980 Census and 1974-1980 Annual Housing Survey are more comparable within themselves.

2/ For 1950, the [illegible] attached category for both owner-occupied and renter-occupied units includes the figure for 1,2 semi-detached.

SOURCE: U.S. Department of Commerce, Bureau of the Census, U.S. Department of Housing and Urban Development:
(a) Annual Survey, 1974, 1977, 1980 United States and Regions General Housing Characteristics, Part A, Series H-150.
(b) Census of Housing, United States Summary, 1940, 1950, 1960, 1970, and 1980.

because of inclusion of unfinished basements and storage areas. This survey reports the average square footage of heated and unheated space was 1,745 square feet and for heated space the average was about 1,500 square feet. Larger housing units were in the colder parts of the country with average heated space decline from about 1,750 square feet in the coldest to 1,270 square feet in the warmest. This relationship primarily reflects the greater proportion of two-story single-family houses with basements in the colder climatic zones. Warmer parts of the country are characterized by more one-story houses without basements. Nationally, single-family housing units average 1,771 square feet of heated floor areas, multi-family 914, and mobile homes 809 (Table B). Regionally, single-family units varied from 2,091 square feet in the Northeast to 1,583 in the South.

There were large differences in the size of housing units occupied by families with different incomes. There was a steady increase in the size of a family's housing unit with its income. Families with 1979 income below $5,000 averaged housing units with 1,041 heated square feet, while families with incomes above $35,000 averaged 2,296 heated square feet of floor area. Heated square footage also increased with the number of household members, from 1,052 square feet for 1 member to 1,476 square feet for 2 members and up to 1,855 square feet for 6 or more members. The estimated heated

Table B. Average Housing Size by Housing Type and Region Per Household, November 1980.

HOUSEHOLD CHARACTERISTICS	HOUSE-HOLDS (MILLIONS)	AVERAGE NUMBER OF SQUARE FEET PER HOUSEHOLD				AVERAGE NUMBER OF HEATED SQUARE FEET PER HOUSEHOLD			AVERAGE NUMBER OF HEATED SQUARE FEET PER HOUSEHOLD MEMBER
		MEAN		MEDIAN					
		HEATED AND UNHEATED	HEATED	HEATED AND UNHEATED	HEATED	SINGLE-FAMILY UNIT	MULTI-FAMILY UNIT	MOBILE HOME	
TOTAL HOUSEHOLDS.............	81.6	1,745	1,499	1,488	1,260	1,771	914	809	534
CENSUS REGION									
NORTHEAST	17.7	1,972	1,623	1,782	1,374	2,091	963	913	572
NORTH CENTRAL	21.1	1,936	1,648	1,840	1,468	1,899	982	794	572
SOUTH	27.0	1,565	1,379	1,296	1,200	1,583	843	787	496
WEST	16.0	1,546	1,368	1,293	1,160	1,624	834	818	502

Source: U.S. Department of Energy, 1982.

square footage was 953 for heads under 25 years of age to 1,773 for heads age 45 to 59. For elderly households, the average dropped to 1,428 square feet.

In 1981 the average finished floor area of a completed privately owned new one-family house was 1,720 square feet. This down slightly from a peak of 1,760 square feet in 1979 and the same level as 1977. Regionally, the Northeast had 1,805 square feet of floor area, the North Central region 1,670 square feet, the South 1,715 square feet, and the West 1,735 square feet (U.S. Bureau of the Census, 1982c). The average floor area has increased moderately since 1970 when the U.S. average was 1,500 square feet, and is substantially above the level of the 1950's when houses averaged about 1,200 square feet. It should be noted, however, that many of the houses built in the 1950's were later enlarged by additions and alterations.

Data on housing production for the United States since 1950 by type of unit is presented in Table C. Total production including mobile homes has varied widely from lows of 1.3-1.4 million in 1957, 1960, 1966, 1975, and 1981 to a peak of almost 3 million in 1972 when government subsidy programs were in full force. Other peaks were 2 million in 1950, 1.8 million in 1955, 1.7 million in 1959, 1.8 million in 1963, and 2.3 million in 1978. These short-term cycles of 4-6 years have been the dominant feature in the housing market since 1950, and are related to changes in credit condi-

Table C.--Housing Production for Total U.S. By Type of Unit, 1950 to 1981 Thousand Units)

Year	Total - All Types	Total Housing Starts	1-Unit Starts	Multi-Unit Starts	Mobile Homes
1950[1/]	2015.0	1952.0	1614.0	338.0	63.0
1951	1558.0	1491.0	1230.0	261.0	67.0
1952	1587.0	1504.0	1257.0	247.	83.0
1953	1515.0	1438.0	1222.0	216.0	77.0
1954	1627.0	1551.0	1371.0	180.0	76.0
1955	1758.0	1646.0	1478.0	168.0	112.0
1956	1473.0	1349.0	1195.0	154.0	124.0
1957	1343.0	1224.0	1026.0	198.0	119.0
1958	1484.0	1382.0	1114.0	268.0	102.0
1959	1674.1	1553.6	1250.6	303.0	120.5
1960	1399.8	1296.1	1008.7	237.4	103.7
1961	1455.2	1365.0	988.0	376.2	90.2
1962	1610.5	1492.5	996.1	496.4	118.0
1963	1785.7	1634.9	1013.4	621.5	150.8
1964	1752.3	1561.0	971.9	589.1	191.3
1965	1726.2	1509.7	964.9	544.8	216.5
1966	1413.1	1195.8	779.5	416.3	217.3
1967	1562.3	1321.9	844.9	477.0	240.4
1968	1863.4	1545.4	900.4	645.0	318.0
1969	1912.2	1499.5	811.2	688.3	412.7
1970	1870.2	1469.0	815.1	653.9	401.2
1971	2581.1	2084.5	1152.9	931.6	496.6
1972	2954.4	2378.5	1310.7	1067.8	575.9
1973	2624.4	2057.5	1133.2	924.3	566.9
1974	1681.8	1352.5	889.1	463.4	329.3
1975	1384.1	1171.4	895.5	275.9	212.7
1976	1793.7	1547.6	1166.4	381.2	246.1
1977	2266.6	1989.8	1452.2	537.6	276.8
1978	2298.9	2023.0	1434.1	588.9	275.9
1979	2028.3	1749.2	1195.6	553.6	279.3
1980	1534.2	1312.6	860.0	452.6	221.6
1981	1341.0	1100.3	711.2	389.1	240.7

[1/] Housing type distribution between 1-unit and multi-unit starts unofficial estimate for 1950-1959.

SOURCE: Bureau of the Census, U.S. Department of Commerce
(a) Housing Construction 1889 to 1964.
(b) Housing Starts 1959 to 1971 Series C20 Supplement.
(c) Housing Start Series C-20 May 1982.

tions. Single-family housing production has varied widely from 1.6 million in 1950 and 1.5 million in 1955 and 1978 to 780 thousand in 1966 and 711 thousand in 1981.

Multi-family production increased from less than 200,000 units in the mid-1950's to over 1 million in 1972 before collapsing to 276 thousand in 1975 and then rebounding to 589 thousand in 1978. Mobile home production rose spectacularly to 576 thousand units in 1972 before crashing to 213 thousand in 1975, and then rose to 279 thousand units in 1979. In 1981, 1,341,000 housing units were produced of which 711 thousand were single-family houses, 389 thousand multi-family units, and 241 thousand mobile homes (U.S. Census Bureau, 1982d).

Regionally, housing production has been increasingly concentrated in the South in recent years. In 1981, 53.8 percent of housing production (including mobile homes) was in the South, 21.6 percent in the West, 14.8 percent in the North Central, and 9.7 percent in the Northeast. Housing production by region has shifted markedly since the 1920's, when about 33 percent of new housing construction was in the Northeast, 27 percent in the North Central region, 24 percent in the South, and 16 percent in the West. In the 1960's and 1970's the South's share of housing production was about 40 percent, the West 25 percent, the North Central region 23 percent, and the Northeast 12 percent (Marcin, 1981).

In 1981, 722 thousand housing

units were produced in the South; of these 367 thousand were single-family houses, 204 thousand were multi-units, and 151 thousand were mobile homes (Table D). In the West, there were 290 thousand units; 150 thousand were single-family houses, 95 thousand multi-units, and 46 thousand were mobile homes (Table E). In the North Central region there were 167 thousand housing units produced; 111 thousand single-family houses, 56 thousand multi-units, and 32 thousand mobile homes (Table F). The Northeast accounted for 131 thousand housing units; 84 thousand single-family houses, 34 thousand mult-units, and 13 thousand mobile homes (Table G).

Yearly shifts in new housing production by type of unit can lead to misinterpretations of what is happening to total housing supply; new housing provides only a small fraction of the overall supply of housing services to consumers. Changing economic and demographic factors lead to cycles in housing production for different types of units over time (Campbell, 1966). For example, major apartment booms occurred in the 1920's and from 1960 to 1973. Overall, since 1900 approximately 70 percent of all housing construction has been single-family housing units (including attached units) and 30 percent multi-unit. The analysis of housing is further complicated by the conversion of existing single-family housing units to multi-family units and emergence of the mobile home. In the 1960's the mobile home became an alternative supply of housing which

Table D. Housing Production for South by Type of Unit, 1959 to 1981

(Thousand Units)

Year	Total-All Types	Total Housing Starts	1-Unit Starts	Multi-Unit Starts	Mobile Homes
1959	567.6	521.3	458.0	63.3	46.3
1960	472.0	441.3	385.2	56.1	30.7
1961	515.8	487.4	414.2	73.2	28.4
1962	586.2	541.1	421.9	119.2	45.1
1963	654.6	595.8	427.0	168.8	58.8
1964	669.4	589.8	419.6	170.2	79.6
1965	681.4	588.6	416.3	172.3	92.8
1966	572.3	482.9	333.5	149.4	89.4
1967	639.9	531.5	365.2	166.3	108.4
1968	779.7	633.7	374.5	259.2	146.0
1969	805.5	602.8	342.7	260.1	202.7
1970	823.9	629.0	378.1	250.9	194.9
1971	1127.9	883.8	526.9	356.9	244.1
1972	1368.7	1067.6	612.7	454.9	301.1
1973	1206.4	905.7	478.8	426.9	300.7
1974	724.3	560.8	367.7	193.1	163.5
1975	542.4	448.4	368.1	80.3	94.0
1976	686.1	574.9	466.5	108.4	111.2
1977	887.2	784.5	588.6	195.9	102.7
1978	959.2	825.8	604.7	221.1	133.4
1979	894.8	749.9	523.6	226.3	144.9
1980	787.8	654.7	432.0	222.7	133.1
1981	722.0	571.2	366.7	204.5	150.8

SOURCE: Bureau of the Census, U.S. Department of Commerce
(a) Housing Construction 1889 to 1964.
(b) Housing Starts 1959 to 1971 Series C20 Supplement.
(c) Housing Start Series C-20 May 1982.

Table E. Housing Production for West by Type of Unit, 1959 to 1981

(Thousand Units)

Year	Total-All Types	Total Housing Starts	1-Unit Starts	Multi-Unit Starts	Mobile Homes
1959	405.7	377.6	265.0	112.6	28.1
1960	341.6	314.6	215.0	99.6	27.0
1961	347.0	323.5	200.1	123.4	23.5
1962	409.4	382.5	210.1	172.4	26.9
1963	467.3	431.8	203.7	228.1	35.5
1964	401.8	362.0	177.1	184.9	39.8
1965	310.6	271.1	159.3	111.8	39.5
1966	238.5	200.0	130.1	69.9	38.5
1967	261.2	223.0	139.2	83.8	38.2
1968	353.3	298.3	170.3	128.0	55.0
1969	387.2	327.2	163.3	163.9	60.0
1970	373.9	314.5	157.2	157.3	59.4
1971	590.6	489.8	242.3	247.5	100.8
1972	646.8	531.5	272.4	259.1	115.3
1973	540.1	431.2	230.1	201.1	108.9
1974	360.4	288.5	176.4	112.1	71.9
1975	332.2	277.7	192.8	84.9	54.5
1976	464.9	402.5	278.1	124.4	62.4
1977	616.7	538.7	370.4	168.3	78.0
1978	622.4	545.8	358.3	187.5	76.6
1979	541.9	471.6	305.7	165.9	70.3
1980	357.7	311.5	198.0	113.5	46.2
1981	290.2	244.4	149.7	94.7	45.8

SOURCE: Bureau of the Census, U.S. Department of Commerce.
(a) Housing Construction 1889 to 1964.
(b) Housing Starts 1959 to 1971 Series C20 Supplement.
(c) Housing Start Series C-20 May 1982.

Table F. Housing Production for North Central by Type of Unit, 1959 to 1981

(Thousand Units)

Year	Total-All Types	Total Housing Starts	1-Unit Starts	Multi-Unit Starts	Mobile Homes
1959	405.8	374.7	327.0	47.7	31.1
1960	334.7	303.7	252.8	50.9	31.0
1961	315.4	289.3	227.3	62.0	26.1
1962	324.8	295.0	215.6	79.4	29.8
1963	373.6	335.9	233.5	102.4	37.7
1964	396.8	346.5	227.3	119.2	50.3
1965	427.2	368.7	225.9	142.8	58.5
1966	358.1	297.3	189.4	107.9	60.8
1967	407.2	343.9	214.3	129.6	63.3
1968	456.7	377.0	222.9	154.1	79.7
1969	461.7	356.6	183.1	173.5	105.1
1970	401.6	301.4	166.4	135.0	100.2
1971	549.8	439.9	238.3	201.6	109.9
1972	560.0	445.3	256.2	189.1	114.7
1973	553.5	442.2	269.1	173.1	111.3
1974	385.3	319.8	225.6	94.2	65.5
1975	343.1	295.4	222.4	73.0	47.7
1976	454.6	400.7	294.4	106.3	53.9
1977	541.9	465.0	337.2	127.8	76.9
1978	500.1	451.3	325.1	126.2	48.8
1979	396.8	349.6	243.9	105.7	47.2
1980	250.5	220.2	142.7	77.5	30.6
1981	198.3	166.8	110.6	56.2	31.5

SOURCE: Bureau of the Census, U.S. Department of Commerce
(a) Housing Construction 1889 to 1964.
(b) Housing Starts 1959 to 1971 Series C20 Supplement.
(c) Housing Start Series C-20 May 1982.

Table G. Housing Production for Northeast by Type of Unit, 1959 to 1981

(Thousand Units)

Year	Total-All Types	Total Housing Starts	1-Unit Starts	Multi-Unit Starts	Mobile Homes
1959	296.0	280.0	200.6	79.4	16.0
1960	251.5	236.5	155.7	80.8	15.0
1961	277.0	264.8	147.2	117.6	12.2
1962	290.1	273.9	148.5	125.4	16.2
1963	290.2	271.4	149.2	122.2	18.8
1964	284.3	262.7	147.9	114.8	21.6
1965	307.0	281.3	163.4	117.9	25.7
1966	244.2	215.6	127.5	88.1	28.6
1967	253.8	223.5	127.2	96.3	30.3
1968	273.7	236.4	132.7	103.7	37.3
1969	257.8	212.9	122.1	90.8	44.9
1970	270.8	224.1	113.4	110.7	46.7
1971	312.8	271.0	145.4	125.6	41.8
1972	378.9	334.1	170.4	163.7	44.8
1973	324.4	278.4	155.2	123.2	46.0
1974	211.8	183.4	119.4	64.0	28.4
1975	166.4	149.9	112.2	37.7	16.5
1976	188.1	169.5	127.4	42.1	18.6
1977	220.7	201.6	156.0	45.6	19.1
1978	217.3	200.1	147.0	53.1	17.2
1979	195.0	178.1	123.7	54.4	16.9
1980	137.9	126.2	87.3	38.9	11.7
1981	130.5	117.9	84.2	33.7	12.6

SOURCE: Bureau of the Census, U.S. Department of Commerce
(a) Housing Construction 1889 to 1964.
(b) Housing Starts 1959 to 1971 Series C20 Supplement.
(c) Housing Start Series C-20 May 1982.

provides service in the form of chattel rather than real estate. Many attributes of a mobile home are similar to single-family houses and they may be considered as a substitute for single-family housing. (The Census Bureau now reports a combined figure for single-family structures and mobile homes).

New regulations have brought the mobile home more and more under the control of the institutional forces in the conventional housing market. As such the mobile home is evolving into another form of industrialized housing. In doing so it is losing many of the attributes of a low-priced form of housing exempt from typical community building codes and real estate taxes.

Historically, the market share of annual housing production has varied widely between single-family and multi-family housing units. The market share of multi-family units ranged between 20 and 45 percent of nonfarm housing starts from 1900 to 1930. From the early 1930's to 1960, the multi-unit market share was abnormally low--between 10 and 20 percent of housing starts--relative to the 30 percent share multi-units had of the total housing inventory in 1940 and 1950. Conversion of large, single-family houses to apartments, rent controls, the fear of rent control, and the highly successful housing mortgage guarantee programs of the Federal Housing Administration and Veteran's Administration contributed to the large market share single-family homes had of the total housing market (Marcin,

1972).

The market share in multi-units increase dramatically in the 1960's, rising from 19.5 percent of housing starts in 1959 to almost 46 percent in 1969. It remained at nearly 45 percent for the period from 1970 to 1973 and then fell to about 24 percent for 1975 and 1976 before rising to 35 percent in 1981. This increase in apartment construction is less dramatic when mobile home shipments are also included in the housing production base. Including mobile homes, the market share of multi-unit structures increased from 18 percent in 1959 to peaks of about 36 percent 1969, 1971, and 1972. It then fell to about 20 percent in 1975 before rebounding slightly to 21 percent in 1976, and 29 percent in 1981.

The apartment boom of the 1960's and early 1970's can be largely explained by (1) the age of the apartments stock in the 1960 (few new structures of five or more units had been produced since the 1920's), (2) an excess supply of single-family houses, (3) a return of housing production to its long-term share of the total housing inventory of about 28 percent, and (4) demographic factors such as the increase in one-person households and the large increase in the number of young households under 30. In the 1980's, middle-aged households age 30-45 will be the dominate factor in the housing market. These groups have traditionally demanded single-family housing. The only demographic trend favoring apartment construction is the continued in-

crease in one-person households.

The market share of mobile homes as a percentage of housing starts plus reported mobile home shipments has increased from about 7 percent in the late 1950's to almost 22 percent in 1969. After staying at a plateau of about 20 percent for the period 1970 to 1974, their market share dropped to 15 percent in 1975, 14 percent in 1976, and 12 percent in 1977. This decline resulted in part from overbuilding and repossession of mobile homes, which caused lenders to be much more conservative in extending credit. In 1981 mobile home market shares rose again to 18 percent.

The mobile homes share of the year-round occupied housing market has increased from 0.7 percent in 1950 to 1.3 percent in 1960 and 3.1 percent in 1970 to 4.6 percent of the housing stock in 1975 and 5.0 percent in 1980.

The mobile home has changed significantly over the last 20 years. For example, the first 10-foot-wide models were introduced in 1955; 12-foot-wide models came into mass production in 1962; and 14-foot-wide models were introduced in 1969. Now expandable models, double-wide models, and even triple-wide models similar to single-family houses are available. The adoption of a nationwide mobile home standard code by the Department of Housing and Urban Development (HUD) in 1976 is a major milestone in the evolution of mobile homes to another form of manufactured housing. This code dictates 2-by-4 framing, insulation, and fire spread standards similar

to conventional construction.

This code, together with government programs to allow long-term mortgage financing on certain types of mobile homes, indicates that the mobile home is now coming under the control of the institutions and regulations of the conventional housing market. As such the mobile home is losing many of the special advantages of being outside the control of the conventional real estate system (Drury 1972). As a sign of the times the Mobile Home Manufactuer's Association has recently changed its name to the Manufactured Housing Institute.

The housing construction process has become increasingly automated over the last 30 years. The changes have been largely in the fabrication of building product components off-site. Building components such as doors, windows, kitchen cabinets, roof and floor trusses, and even entire wall panels and bathroom cores are constructed in factories or shops and assembled on-site. Pre-finished molding, trim, and siding are often used as well as automatic nailing and fastening machines to reduce on-site labor and speed the construction process. Thus, although the house of the 1980's looks similar to the house of the 1950's its construction methods are more automated. Pre-manufactured components are now assembled on the building site and relatively few "stick-built" houses are constructed anymore.

A recent telephone survey of housing companies by Leo J. Shapiro & Associates, Inc., of Chicago, indicated that the total

market share of mobile, modular and panelized in-plant fabricators of housing rose from 39 percent in 1980 to 42 percent in 1981 (Automation in Housing, 1982). This survey was conducted by interviewing 353 representative building companies about their production methods. The results of this survey are summarized in Table H. According to this survey, in 1981, 315 thousand, or 27 percent of convention construction (excluding mobile homes) was classified as panelized or prefabs, 52 thousand or 4 percent modular and 810 thousand or 69 percent production (on-site) built housing units. In addition an estimate of 229 thousand mobile homes are produced according to the survey.

Estimates of the number of plant location and housing component manufacturer's is also provided. These results show a large number of companies in the housing industry. There were an estimated 6,148 companies with over 11,000 plant locations in 1981. These figures show that diversity, specialization, automation, and innovation are all possible in the construction industry.

TABLE H.

ESTIMATED HOUSING PRODUCTION: 1978 - 1981

INDUSTRY SEGMENTS BY HOUSING PRODUCTION
IN 1978, 1979, 1980, 1981 (THOUSANDS)

	1978	1979	1980	1981	Percentage Point Change 1980 to 1981
Production Builders	1276	1284	966	810	(-16%)
Panelized-Prefab	463	449	352	315	(-11)
Modular	87	81	56	52	(-7)
Mobile Homes	276	286	216	229	+6
Total Without Mobile Homes	1826	1814	1374	1177	(-14)
With Mobile Homes	2102	2100	1590	1406	(-12)

Source: Automation In Housing, and Systems Building News, Vol. 19, No. 1, January, 1982

TABLE I

ESTIMATED NUMBER OF REPORTING UNITS, COMPANIES AND PLANTS IN 1981

	Companies	Locations/ Plants
Production Builders	3,124	7,691
Panelized Prefab	635	650*
Modular	218	225*
Mobile Homes	171	454
Sub-Totals	4,148	9,020
Independent Component Manufacturers (Furnish components to other four segments)	2,000*	2,000*
	6,148	11,020

*AIA/SBN Estimates

Source: Automation In Housing, and Systems Building News, Vol.19, No. 1, January, 1982

WOOD PRODUCTS USED IN HOUSING

Building materials used in residential construction have changed substantially since 1950. However, wood products remain the dominant material used for home building--over 90 percent of all new single-family homes are wood framed. Traditional housing styles have prevailed while new building systems using plastics, metals, or cement products, or featuring unusual styles have in general not been very successful.

Wood products use per housing unit has also changed substantially in the last 30 years. Wood products use per housing unit varies widely with the type of unit, its size, architectural style, regional location, and kind of construction. Plywood and other wood-based panel products have replaced lumber for many construction uses. Changes in construction methods and trends in the substitution of alternative materials are also important for determinants of wood use per unit.

The greater use of prefabricated housing components and even entire housing units have tended to lower average unit use factors for some wood products. The use of roof trusses has increased greatly in the last 20 years, and now floor trusses are being used in place of traditional floor joist systems in some areas (Kallio 1978). Other building components such as doors, windows, and cabinets are now almost universally manufactured in factories and only put in place on-site. In addition, wall systems, floor systems, and some-

times entire modules are manufactured or prefabricated in factories and assembled on-site. Better design and reduction of waste from increased industrialization of housing production could result in lower average wood use per unit.

In conventional on-site construction, more efficient use of wood such as wider spacing of studs and other structural members has tended to bring about somewhat lower use of timber products per unit (USDA Forest Service 1973). There are also opportunities for additional savings in use of materials by changes in design and specification. For example, a promising new design idea is the lightweight truss-framed house developed at the Forest Products Laboratory. This design utilizes a unitized frame consisting of an open web floor system, trussed rafters, and conventional wall studs all using 2-by-4 lumber (Tuomi 1977).

Changing Housing Characteristics

The average new house increased dramatically in size and amenities in the United States since 1950. These changes reflect, in part, a doubling of per capita real disposable income and a general rise in housing standards. The average single-family housing unit has increased from 983 square feet of finished floor area in 1950 to 1,760 square feet in 1979 before declining slightly to 1,740 square feet in 1980 (Sheeha 1979 and U.S. Bureau of Census 1981).

As houses grew in size, the number of bathrooms and bedrooms

increased. In 1950 about two-thirds of all new homes had two bedrooms or less, by 1977 only 11 percent had less than three bedrooms; however, by 1980 this number had risen to 17 percent. Perhaps nothing indicates the rise in housing standards as much as the increase in the number of bathrooms. In 1950, over 25 percent of all existing dwelling units did not have inside flush toilets. Almost all new houses (92 percent) in 1950 had only one bathroom. By 1980, 73 percent of all new houses had two or more bathrooms (16 percent had one, and 10 percent had 1½).

Other major amenities added to houses since 1950 include central air conditioning, dishwashers, garbage disposals, trash compactors, and central vacuum systems. In 1950, with the advent of central heating, a fireplace was considered a costly luxury and only 22 percent of the new houses had one. In 1980, 56 percent of newly built houses had fireplaces, despite their inefficiencies as an alternative heating device.

Major structural and architectural changes are particularly significant in determining wood products' use. These include type of foundation, number of stories, kind of garage, if any, regional architectural style, and changes in architectural styles through time such as fewer porches and smaller eave overhangs.

The type of foundation is particularly important for wood use. Houses built on a concrete slab foundation do not have a conventional joist floor system and therefore use less wood.

Conversely, the recently developed all-weather wood foundation uses substantially larger amounts of wood. The use of concrete slab foundations has grown from 12 percent in 1950 to 45 percent in 1980. Construction of houses with slab foundations is most common in the South and West with nearly all houses built on slabs in such fast-growing states as Florida, Texas and Arizona. As population shifts continue to favor these areas, the proportion of houses with slab construction may rise slowly. Of the houses built in 1980, 36 percent had basements, principally in the Northeast and North Central regions, and 19 percent had crawl spaces.

The percentage of new single-family houses with garages has grown from 40 percent in 1950 to 76 percent in 1980--including 62 percent which had two-or-more car garages. The trend to large garages reflects, in part, growth in household income and increased number of automobiles per household.

The proportion of two-story houses built has increased greatly since 1950--31 percent in 1980 versus about 10 percent in the 1950's. Correspondingly, one-story houses have declined from 86 percent in 1950 to 59 percent in 1980 (U.S. Bureau of Census 1981 and U.S. Bureau of Labor Statistics 1968).

Split-level houses accounted for 9 percent of those built in 1980. This type of construction reduces substantially the roof area and reduces lumber use per square foot of floor area. Two-story construction permits en-

larging the house size without increasing the size of the building lot, a factor that should become increasingly important in the current era of rapidly rising land prices.

Other architectural changes include the virtual disappearance of porches that were once a feature of nearly all one-family houses. In addition, roof overhangs have decreased in size or have been eliminated. Recently, however, many houses have been built with wooden decks which serve many of the purposes of earlier porches.

Housing production is now greatest in the fast-growing regions of the South and the West. For example, in 1980, 49.7 percent of housing starts were in the South, 23.7 percent in the West, 16.0 percent in the North Central region, and only 9.7 percent in the Northeast. California, Florida, and Texas alone account for about 35 percent of all housing built in the United States in 1980 (U.S. Bureau of the Census 1981).

Trends in Lumber Use

Lumber continues to be the dominant framing material for new housing construction despite the long term rise in lumber prices relative to other commodities. In fact, lumber increased its dominance at the expense of masonry walls. In 1980 about 92 percent of all single-family house exterior walls were wood as compared to 82 percent in 1959. Masonry walls fell from 18 percent on new housing units in 1959 to 7 percent in 1980; poured concrete and steel studs and other framing

systems were insignificant, consisting of only one percent of exterior walls. Steel and aluminum framing systems have been developed, but their use has been limited. Wood still has a comparative cost advantage; however, should lumber become unavailable or extremely costly, metal framing systems could become cost competitive and threaten lumber's dominance in residential framing (Spelter 1979). Underground earth shelter systems could also challenge wood's dominance in northern climates.

Framing is the most important use of lumber in housing. However, other miscellaneous uses also account for considerable amounts of lumber. These include sheathing, siding, stairways, trim, millwork, garage doors, decks, and manufactured doors, windows, and cabinets (Phelps 1971). Framing accounts for about 70 percent of lumber use in single-family houses and miscellaneous uses about 30 percent. (Table J.)

Total lumber use per housing unit has not changed much in the last 20 years. However, use per square foot of floor area has declined. Use per square foot of floor area fell from 11.0 board feet in 1950 to 8.7 in 1962 and 7.0 in 1980. These changes in lumber use can best be illustrated by comparing the average one-family house built in 1950 with the average unit built in the 1970's.

The typical post-war home utilized a considerable amount of lumber. The spacing of wall and floor members was 16 inches with additional material used for wall

Table J. Lumber Products for Housing Units Completed in 1980 For Various Housing Types and Regions of the United States

Material (Bd. Ft.)	New England	Mid-Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	United States
				Single-Family Detached						
Framing Lumber	9362	10,736	9236	8816	7353	7889	7945	7673	9796	8477
Non-Framing Lumber	3467	3136	1866	1845	1776	1633	1777	1672	2965	1984
Exterior Doors	83	99	73	136	112	103	146	145	236	133
Interior Doors	391	328	184	386	320	310	200	130	117	232
Windows	437	366	257	350	169	75	17	29	0	149
Decks & Fences	366	309	310	391	335	241	111	119	329	236
Finished Flooring	342	309	15	23	75	25	6	11	26	65
Roofing	33	33	33	211	40	53	337	315	1103	276
Sheathing Lumber	609	195	316	157	325	260	344	271	1170	423
TOTAL	14,371	16,322	12,155	13,835	10,316	10,496	10,072	10,366	15,599	11,953
				Single-Family Attached						
Framing Lumber	7023	6009	5004	7176	4161	6100	6109	61,105	6624	5854
Non-Framing Lumber	1779	1640	1336	1092	1596	1772	1768	1468	1616	1597
Exterior Doors	68	28	80	136	37	117	81	97	124	87
Interior Doors	83	183	80	340	94	239	110	116	36	109
Windows	140	122	90	306	43	164	5	13	5	58
Decks & Fences	300	262	136	375	449	539	150	110	136	249
Finished Flooring	12	80	12	0	0	30	2	7	25	10
Roofing	0	7	113	277	21	0	62	215	509	186
Sheathing Lumber	760	195	737	326	130	333	145	130	172	212
TOTAL	10,304	8592	7880	10,632	6516	9370	8499	63,360	8621	8130
				Multi-Family Low-Rise						
Framing Lumber	6250	3056	6351	4006	3131	6377	3736	4000	5942	4377
Non-Framing Lumber	3164	899	991	1227	890	1031	1356	954	1662	1232
Exterior Doors	80	11	30	20	19	35	119	39	70	56
Interior Doors	170	50	47	130	103	102	87	48	24	71
Windows	133	10	34	55	7	2	1	4	2	15
Decks & Fences	640	130	63	176	303	309	363	43	139	154
Finished Flooring	23	0	30	0	0	0	0	0	0	4
Roofing	0	0	1	0	11	0	7	40	131	33
Sheathing Lumber	700	0	30	71	33	31	104	52	144	94
TOTAL	10,080	4190	5884	6068	4306	5058	5540	6007	8120	6034

bracing and double-layer board sheathing. Roofs consisted of ceiling joists and roof rafters connected by collar beams and placed over a load-bearing interior partition. Boards served for sheathing as well as for soffits.

In the 1970's, boards are seldom used for sheathing either in floors, walls, or roofs because panel products have taken over the sheathing markets. Plywood has been commonly used for soffits and siding. Let-in corner bracing has become superfluous because the glued-on plywood panels impart greater rigidity to walls. This greater strength has resulted in increasing numbers of homes being built with 24-inch floor and wall spacing instead of 16 inches. And in roofs, the emergence of the engineered roof-truss has enabled great economics due to wider spacing and use of smaller length pieces of lumber. The impact of these trends can best be illustrated by focusing on the main components of a house.

In <u>floor-framing</u>, lumber usage dropped sharply in the 1950s as the number of houses built on concrete slabs rose. The proportion of units built in this manner was small in the immediate post-war period but rose sharply thereafter. The reason for this shift was an increase in the proportion of homes built in the South and Southwest, where units were more likely to be built on concrete slabs.

The wider spacing of floor joists has also been reducing lumber use in floors over the past ten years. When plywood sheathing is glued onto the floor

joists, the panels bind the members into T-beam units which result in increased stiffness. The American Plywood Association has been promoting 24-inch joist spacing as a material-saving technique and they have found that the proportion of nonslab conventionally built homes using 24-inch spacing rose from 1 percent in 1968 to 9 percent in 1976 (Carney 1977).

The impact of wider stud spacing is evident in the data on lumber use in wall-framing (interior and exterior). The use factor declined by 12 percent from 2.5 in 1959 to 2.2 in 1976. This trend could be offset somewhat by increased use of 2-by-6 studs because of higher insulation requirements.

In roof-framing the use factor declined because of the adoption by the construction industry of the roof-truss over the ceiling joist-roof rafter method. The savings resulted primarily from the wider spacing of the members made possible by the greater strength of the truss. In a typical 28-foot wide house, 42 percent saving of roof lumber can be realized (Saeman 1974).

In nonframing applications, lumber use has dropped more sharply. The use of board lumber in subflooring, sheathing, and siding has been drastically reduced as a result of competition from panel products, chiefly softwood plywood and particleboard. In millwork, lumber's position remained relatively stable in the 1960s and is estimated to have altered little in the 1970s.

There were substantial re-

gional variations in lumber use. Western homes have typically used the greatest amount of lumber per square foot of floor area due to an above-average preference for lumber sheathing and subflooring. The North Central and the the Northeast regions were next highest because of the greater use of lumber in floors for basements. The Southern use factor was usually the smallest because of the high incidence of slab-built homes and lower than average lumber use in walls, reflecting a high proportion of homes built with concrete blocks, particularly in Florida.

Trends in Wood-Based Panel Products Use

Wood-based panels are used extensively in residential construction in the United States. Major uses of panel products in residential construction are for roof and wall sheathing, floor decking, exterior siding, and interior decorative wall paneling. In addition, substantial amounts of panels are also used for doors, cabinets, shelving, and other miscellaneous uses. Wood-based panel use varies substantially by region in the United States, because of differences in climate and architectural styles.

For single-family detached, single-family attached and low-rise multi-family construction which constitute over 95 percent of all residential construction, plywood remains the dominant panel product. Individual components are discussed below.

Roof sheathing is one of the most important uses of wood-based

panels in residential construction. Softwood plywood is the dominant material for roof sheathing since it displaced lumber boards in the 1950's. Eighty-eight percent of all roofs used plywood in 1980; the remainder used solid or spaced boards. This high level of plywood roof sheathing is fairly consistent for all regions except for the Pacific, where wood shingles are often applied over lumber sheathing. In the 1980s, structural particleboards and veneer composite boards are expected to gain a share of this market when single-family housing construction expands again (Dickerhoff 1980).

The exterior wall sheathing market has changed dramatically since 1974 as a result of the energy crisis. In 1974, wood fiber insulating board accounted for 58 percent of the exterior wall sheathing used, plywood 27 percent, gypsum board 14 percent, and 1X lumber boards 1 percent (Housing Industry Dynamics 1980). Since then several types of plastic foam sheathing and an aluminum foil-faced sheathing have been developed which offer relatively high insulation values per unit of thickness. By 1980, the plastic foam sheathing products had gained a 26 percent share of the single-family construction market and the aluminum foil-faced sheathing a 12 percent share. Correspondingly wood fiber insulation's share fell to 35 percent, plywood's to 18 percent, and gypsum board's to 8 percent. Further shifts to foam sheathing panels are likely in the next few years as energy efficiency stan-

dards rise. Recently developed structural particleboards gained 2 percent of the exterior wall sheathing market in 1980. Further gains are anticipated in the future as housing construction increases.

Floor decking is a major market for wood panel products. Wood products were used for subfloors in over 99 percent of all single-family houses built on nonslab foundations. Wood floor systems are popular in the Northeastern and North Central regions of the United States. In 1980 plywood was used for subflooring in 93 percent of nonslab foundation houses, lumber boards in 3 percent, and structural particleboards in 3 percent; 38 percent of these houses had a second layer of floor underlayment. Of this underlayment, 60 percent was particleboard, 37 percent plywood, and 3 percent hardboard. Wall-to-wall carpeting is the dominant floor covering material. Wood flooring accounted for only about 5 percent of the finished floor area in 1980. The floor decking market is likely to continue to be served primarily by plywood and particleboard, with new types of structural composite boards also gaining a share of the market.

The exterior wall siding market has shown gradual gains in wood use in recent years. Forty-two percent of all houses built in 1980 used some type of wood product for exterior siding--an increase from 32 percent in 1974. By type product, 19 percent was hardboard, 12 percent plywood, and 11 percent lumber. Most of the gain in wood products use for

siding came at the expense of brick and other masonry finishes. Wood panel products are expected to continue to gain in popularity in the future because of the relatively high cost of bricks and other masonry alterations.

Interior decorative panel products are also used widely in new residential construction in the United States. About one-third of all new houses use some type of prefinished panel; most of this paneling is some type of plywood. This market is expected to remain about the same in the future.

Prospects

The use of lumber in residential construction has steadily declined on a per square foot of floor basis since the 1950's. This trend is likely to continue, albeit for different reasons than was the case in the past.

Of the major trends in the past, the one that will be the least significant in the future is the displacement of board lumber by plywood. Lumber has already been effectively eliminated in the markets where the two products compete, so further losses will be limited. Material savings, on the other hand, will continue to be a factor as overspecification and inefficient lumber use is still widespread despite progress in the use of trusses and improved designs. The development of the lightweight truss-framed house is another step in the further economies of wood.

Of the major trends in the past, the one that will have the least significance in the future

is the displacement of boards by plywood in sheathing, subflooring, and soffits. Lumber has already been effectively eliminated in these markets and future losses will be small. Material savings, on the other hand, will continue to be a factor as overspecification and inefficient lumber use is still the rule rather than the exception despite considerable progress in use of trusses and improved designs.

With the likelihood that lumber will remain the dominant residential construction framing material, lumber use could still drop because of material savings from wider stud spacing, increased truss use, and the loss of the remaining sheathing markets. Assuming that the 1959 framing-use factors largely reflected 16-inch spacing, potentially lower use factors can be calculated for 24-inch framing. The estimated maximum possible savings in walls is 25 percent and 40 percent on roofs. Wood joist floor systems could be reduced 25 percent; however, the overall use per square foot of floor area is also affected by the proportion of concrete floor.

Comparing recent usage survey data with data for 1959 reveals that the roof-use factor was 27 percent less than in 1959, indicating the substantial takeover by trusses in the roof-framing market. Comparisons in floor usage rates show a 25 percent decline over the same 21-year period. However, this reflects the increased use of concrete slab flooring rather than wider joist spacing. Wall-framing use was shown 19 percent indicating

limited downward potential there. Potential increases in floor truss use may also decrease lumber use, particularly for wide dimensions.

Trends that may work to increase lumber use in housing include the All Weather Wood Foundation (AWWF) and the Plen-Wood system, both designed to compete with concrete systems (American Plywood Association 1976). The AWWF in particular has gained a foothold in the market with potentially steadily rising use. The widespread adoption of the system at the expense of concrete foundations could boost lumber uses greatly. The Plen-Wood System is more economical than poured concrete slab, but the system is relatively new with little marketing success to date.

The AWWF, which is targeted to compete with concrete foundations, is easy to install, costs less than concrete, and can be erected in freezing weather. Over 20,000 new homes have been built on AWWF since its introduction in 1970, suggesting substantial builder and consumer acceptance (Dost 1977).

Because Pen-Wood is a more recent development, few homes have as yet been built on it, but a study has indicated it to be more economical than concrete slab flooring. The system involves insulating the space between the ground and the floor. The air is heated and circulated throughout the home through openings in the floor, eliminating the need for ductwork. The system is likely to gain impetus due to

recurring cement shortages.

In summary, the prospects for lumber-framing use in residential construction are for continued moderate declines due to material savings. It is unlikely that nonwood materials will displace lumber due to higher energy costs. This factor may benefit lumber use due to displacement of more energy intensive concrete floors and foundations. The use of wood trusses is likely to continue to increase as new and better designs are developed.

Wood-based panel products are expected to continue to be the major sheathing product for residential construction in the future. However, wood fiber insulation board is expected to have a declining share of the wall sheathing market because of the increased use of plastic foam insulation boards. The development of structural composite panels made of wood flakes or fibers is expected to provide competition for softwood plywood in these markets (Dickerhoff 1980). Structural composite panel products production is currently based on low-cost hardwood resources in the Midwestern and Eastern United States and Canada. Their production costs are generally lower than plywood and their performance equivalents. Therefore, structural panel products are likely to gain a 10 to 20 percent share of the sheathing market in the next 10 years as building codes and consumer acceptance increases. In summary, the wood-based panel product market is likely to maintain or expand its current uses for residential construction, and

substantial competition will develop between the various types of products.

Expenditures for Residential Upkeep and Improvement

Expenditures for upkeep and improvement of all residential properties in 1981 were estimated at $46.4 billion according to the U.S. Department of Commerce Bureau of the Census (U.S. Census Bureau, 1982). This estimate is about the same as the 1980 estimate of $46.3 billion. About 70 percent or $32.2 billion was spent by resident owners of properties with one to four housing units. Expenditures for additions, alterations, and major replacements amounted to $30.3 billion in 1981 while expenditures for maintenance and repairs were estimated at $16.0 billion.

A more detailed look at expenditures for upkeep and improvements of residential properties shows construction improvement to have declined from $31.2 billion in 1980 to $30.3 billion in 1981. Of this total $20.4 billion were for additions and alterations and $9.9 billion for major replacements in 1981 (Table K). Expenditures for upkeep increased from $15.2 billion in 1980 to $16.0 billion in 1981, of which painting accounted for $5.6 billion, or 35 percent, and plumbing, heating, and air conditioning $2.6 billion or 16 percent.

Expenditures for residential additions and alterations declined from $21.4 billion in 1980 to $20.4 billion in 1981. However, alterations within residential structures rose from $11.2 billion to over $11.9 billion while additions fell from $10.0 billion to $9.5 billion (Table K). In terms of constant infla-

Table K. Expenditures for Upkeep and Improvement of Residential Properties By Size of Property and Type of Construction Work: 1980-1981

(In millions of dollars. Detail may not add to total due to rounding)

Type of Construction work	1980	1981	1981		
	All residential properties		Owner-occupied properties with-		One to four unit properties with no resident owner and all properties with five or more housing units
			One to four housing units	One housing unit	
Total Expenditures	46,338	46,350	32,236	30,201	14,115
UPKEEP					
Maintenance and repair	15,187	16,022	8,468	7,844	7,554
Heating and central air conditioning	972	750	419	378	331
Plumbing	1,606	1,870	896	789	974
Roofing	1,172	1,574	1,063	981	512
Painting	5,709	5,576	3,423	3,212	2,153
Siding	560	620	307	267	313
Other	5,168	5,632	2,360	2,216	3,272
CONSTRUCTION IMPROVEMENT					
Additions, alterations and major replacements	31,151	30,329	23,768	22,357	6,561
Additions to residential structure	4,183	3,164	2,788	2,695	376
Additions and alterations on property outside residential structure	5,960	5,303	4,895	4,510	408
Alterations within residential structure	11,193	11,947	9,330	8,766	2,617
Heating and central air conditioning	876	891	826	805	65
Plumbing	797	710	511	511	199
Remodeling	2,620	3,468	2,132	2,126	1,336
Other	6,900	6,877	5,860	5,324	1,018
Major replacements	9,816	9,915	6,756	6,387	3,159
Heating and central air conditioning	2,459	2,028	1,273	1,112	754
Plumbing	1,577	1,838	1,122	1,023	716
Roofing	3,160	3,352	2,464	2,358	887
Siding	1,486	1,517	1,301	1,301	216
Other	1,134	1,181	596	593	585

Source: U.S. Bureau of Census Series C-50.

tion adjusted 1977 dollars, additions and alterations were $12.9 billion in 1981, down from $14.7 billion (1977 dollars) in 1980, and the lowest level since 1974. Since 1960, inflation adjusted expenditures for alterations and additions have increased only modestly, declining slightly from $11.3 billion (1977 dollars) in 1960 to $11.1 billion (1977 dollars) in 1970 before rising to $14.7 billion (1977 dollars) in 1980. In the first half of 1982, these expenditures were at an annual rate of $11.6 billion (1977 dollars) or about the same level as 1960.

The residential upkeep and improvement sector of the housing construction market is cyclically sensitive like the market for new housing. Real expenditures for this sector decline during recession periods because of the impact of declining income and the inability of consumers to obtain financing for major projects. The decline in expenditures for residential alteration and repairs is less severe than for new construction, but it is significant and contradicts the popular notion that expenditures for residential upkeep and improvement increase during periods of economic recession.

Total expenditures have moved unevenly upward during economic good times, more than tripling from the 1970 level of $14.8 billion by 1980 (Table L). However, most of this increase is because of inflation. In terms of constant 1977 dollars, expenditures increased from $26.0 billion in 1970 to $32.7 billion in 1980 before falling to $29.9

Table L. Expenditures by All Residential Property Owners For All Maintenance and Repairs 1966-1981

(in millions of dollars)

Total	Total Expenditures	Pct. Chg.	Maintenance & Repairs	Pct. Chg.	Additions & Alterations	Pct. Chg.	Major Replacements	Pct. Chg.
1966	$ 11,691		$ 4,803		$ 4,976		$ 1,912	
1967	11,687	0.0	4,431	-7.7	5,321	6.9	1,935	1.2
1968	12,703	8.7	5,186	17.0	5,314	-0.1	2,202	13.8
1969	13,535	6.5	5,479	5.6	5,885	10.7	2,170	-1.5
1970	14,770	9.1	5,895	7.6	6,211	5.5	2,629	21.2
1971	16,299	10.4	6,361	7.9	6,818	9.8	3,120	18.7
1972	17,498	7.4	6,717	5.6	7,526	10.4	3,255	4.3
1973	18,512	5.8	7,924	18.0	7,386	-1.9	3,202	-1.6
1974	21,114	14.1	8,491	7.2	8,060	9.1	4,563	42.5
1975	25,239	19.5	9,578	12.8	10,997	36.4	4,484	-1.7
1976	29,034	15.0	11,379	18.8	12,314	12.0	5,341	19.1
1977	31,280	7.7	11,344	-0.3	14,237	15.6	5,699	6.7
1978	37,461	19.8	12,909	13.8	16,458	15.6	8,094	42.0
1979	42,231	12.7	14,950	15.8	18,285	11.1	8,996	11.1
1980	46,338	9.7	15,187	1.6	21,336	16.7	9,816	9.1
1981	46,350	0.0	16,022	5.5	20,414	-4.3	9,915	1.0
Single Family Owner Occupied								
1966	$ 7,133		$ 2,067		$ 3,928		$ 1,138	
1967	7,024	-1.5	1,935	-6.4	3,994	-1.7	1,094	-3.9
1968	8,089	15.2	2,350	21.4	4,315	8.0	1,424	30.2
1969	8,594	6.2	2,469	5.1	4,740	9.8	1,384	-2.8
1970	9,469	10.2	2,753	11.5	4,974	4.9	1,742	25.9
1971	10,234	8.1	2,853	3.6	5,366	7.9	2,015	15.7
1972	11,128	8.7	3,193	11.9	5,808	8.2	2,127	5.6
1973	11,297	1.5	3,620	13.4	5,688	-2.1	1,989	-6.5
1974	13,578	20.2	4,031	11.4	6,441	13.2	3,106	56.2
1975	15,684	15.5	4,540	12.6	8,458	31.3	2,685	-13.6
1976	18,854	20.2	5,217	14.9	10,231	21.0	3,407	26.9
1977	21,761	15.4	5,705	9.4	12,015	17.4	4,042	18.6
1978	24,189	11.2	6,427	12.7	12,624	5.1	5,138	27.1
1979	28,280	16.9	7,603	18.3	14,677	16.3	6,000	16.8
1980	31,481	11.3	7,532	-0.9	17,244	17.5	6,705	11.8
1981	30,201	4.1	7,844	4.1	15,970	-7.4	6,387	-4.7
All Other Residential								
1966	$ 4,558		$ 2,736		$ 1,049		$ 774	
1967	4,663	2.3	2,496	-8.8	1,327	26.5	842	8.8
1968	4,614	-1.1	2,836	13.6	999	-24.7	779	-7.5
1969	4,941	7.1	3,010	6.1	1,145	14.6	786	0.9
1970	5,301	7.3	3,143	4.4	1,237	8.0	887	12.8
1971	6,065	14.4	3,508	11.6	1,452	17.4	1,105	24.6
1972	6,371	5.0	3,524	0.5	1,717	18.3	1,128	2.1
1973	7,215	13.2	4,304	22.1	1,698	-1.1	1,213	7.5
1974	7,536	4.4	4,459	3.6	1,620	-4.6	1,456	20.0
1975	9,555	26.8	5,218	17.0	2,539	56.7	1,799	23.6
1976	10,180	6.5	6,162	18.1	2,083	-18.0	1,934	7.5
1977	9,519	-6.5	5,639	-8.5	2,222	6.7	1,657	-14.3
1978	13,272	39.4	6,482	14.9	3,834	72.5	2,956	78.4
1979	13,951	5.1	7,347	13.3	3,618	-5.6	2,996	1.4
1980	14,857	6.5	7,655	4.2	4,092	13.1	3,111	3.8
1981	16,149	8.7	8,178	6.8	4,444	8.6	3,528	13.4

Source: U.S. Bureau of Census, Series C-50. Compilation by NAHB Economics Division.

billion in 1981. Real expenditures from residential alterations and repairs per household rose from $410 (1977 dollars) in 1970 to $440 in 1976 before declining to $363 in 1981. In the future it is expected that expenditures for residential repair and alteration will remain at about an average of $400 (1977 dollars) per occupied housing unit and total expenditures will rise as number of housing units increases.

The type of additions and alterations undertaken by single-family homeowners is illustrated by a recent survey conducted in the spring of 1982 by the Economics Division of the National Association of Homebuilders (NAHB) in conjunction with National Home Center News (NAHB, 1982). In response to the question "What are the major additions and alterations completed and appliances purchased during the last 12 months and/or those you plan to complete or purchase within the next 24 months?" the most commonly completed projects were "remodeled kitchen" by 9.6 percent, "change roof" by 8.7 percent, "changed water heater" by 8.4 percent of the homeowners and "finished basement/rec room" by 6.2 percent. Of these projects the most commonly done by homeowners themselves were "remodeled kitchen" by 5.1 percent, "finished basement/rec room" by 4.4 percent, "changed water heater" by 4.3 percent, and "changed roof" by 3.2 percent (Table M). Future building plans are considerably lower than completed projects. This may be because of three

Table M Major Additions and Alterations Completed by Recent Home Buyers in 12 Months Ending April 1, 1982 with Future Plans.

	Completed				Plan To Do	
	Did It Myself	Contractor Did Work	Myself and Contractor	Total	In Next 12 mos.	In Next 12-24 mos.
Finished Basement/Rec Room	4.4%	0.5%	1.3%	6.2%	0.9%	2.3%
Finished/Added Den	1.7	0.7	0.2	2.6	0.4	0.4
Added Bedroom	1.0	0.6	0.9	2.5	0.2	0.5
Added Full Bath	1.3	0.9	0.7	2.9	0.2	0.6
Added Powder Room	-	-	0.6	0.6	-	-
Added Second Story	0.2	0.1	0.4	0.7	-	0.2
Added Fireplace	1.2	0.9	0.4	2.5	0.2	1.0
Added Garage:						
One Car	0.2	-	0.2	0.4	0.2	-
Two Car	0.9	0.7	0.7	2.3	0.2	0.2
Changed Roof	3.2	5.0	0.5	8.7	2.4	1.7
Changed Siding	1.2	1.5	0.4	3.1	0.2	0.7
Remodeled Kitchen	5.1	2.8	1.7	9.6	1.1	2.2
Changed/Added A/C Unit	1.5	2.0	0.6	4.1	1.0	1.0
Changed Heating System	2.4	3.1	1.0	6.5	0.5	1.1
Changed Water Heater	4.3	3.5	0.6	8.4	1.0	0.4
Added Porch/Solar Room	0.7	1.0	0.4	2.1	0.6	0.4
Added Deck	1.6	0.7	0.7	3.0	1.6	1.2
Added Patio	1.7	1.1	0.6	3.4	1.3	0.5
Covered/Enclosed Existing Deck, Patio, Porch	1.8	1.5	0.5	3.8	1.8	0.7
Finished Attic	0.6	0.4	0.1	1.1	0.1	0.2

Source: NAHB Economics Division

reasons: First, homeowners may have included some major projects completed longer than 12 months previously; second, some projects such as "changed roof" may be unplanned necessities; and third, the uncertain economic outlook in the spring of 1982 may have made consumers' extra cautious about planning projects involving major expenditures.

In summary, there is an apparent trend toward housing rehabilitation and recycling of some highly visible residential and nonresidential structures. Thousands of older structures are being rebuilt, restored and renovated in certain desirable locations of older cities. The old brick row houses of Baltimore, Philadelphia and Washington are examples. Throughout older formerly fashionable sections of many cities--such as the brownstones of New York and Chicago--structurally sound houses are being reconstructed. On the other hand, many less desirable housing units in other areas are not being improved. Energy obsolete housing may be uneconomical to retrofit. Overall statistics on expenditures for residential alteration and repair show no overall boom in rehabilitating the present housing stock. A major boom in renovation of the existing housing stock occurred from 1975 to 1980, spurred by the need for improved energy conservation and by the general boom in housing. Remodeling often occurs when new homebuyers change an existing house to fit their preferences. This occurs during periods of high home sales not during construction depressions. Thus, un-

less there are deliberate policies to supress new housing construction, new construction is likely to be the major sources of housing in the remainder of the 1980's assuming real interest declines to their historical norms of about 3 percent and economic growth resumes. Residential alteration and repair expenditures are likely to grow at its historical rate relative to inflation and the growth in the total stock of housing units.

Wood Products Use for Residential Upkeep and Improvement

Building materials used for upkeep and improvement to existing residential structures are most likely to be similar to building materials used for new residential construction. Most housing units are repaired using materials similar to those involved in the original construction. Some categories of maintenance and repair can be eliminated as major uses of wood such as painting, plumbing, heating and air conditioning. Wood products used for residential additions and alterations are likely to be similar to those for new construction. Some wood products such as interior paneling and exterior siding may be more likely to be used in residential improvements, while others such as framing lumber and exterior sheathing are likely to be used relatively less.

Data on wood products use for residential alteration and repair is sketchy because of nebulous character of the market and the difficulty in obtaining a comprehensive estimate of homeowners'

use for various projects. An extensive survey was conducted in 1970 by the U.S. Forest Service of residential alteration and repair jobs which required building permits. On-site interviews were conducted and estimates of materials made. While unpublished information from this study is somewhat dated, it does provide some useful insights into wood products use for this sector. For the United States 478 jobs were sampled with an average expenditure of $2,126 (1970 dollars). Major additions averaged $3,183, alterations inside $2,7911, alterations outside $1,684, replacement projects $1,373, and maintenance and repair work $1,370 in terms of 1970 dollars. Inflating these figures to 1981 dollars using the consumer price index would yield an average job cost of about $5,200 for all projects, $7,500 for additions, $6,200 for inside alterations, $4,000 for outside alterations and about $3,200 for major replacement, maintenance and repair jobs.

Structural lumber use averaged 544 board feet (bd. ft.) per job and 256 bd. ft. per $1,000 (1970 dollars) of job value. Total lumber use including millwork, averaged 360 bd. ft. per $1,000 (1972 dollars). Additions averaged 1,229 bd. ft. of structural lumber use, inside alteration 555 bd. ft. and outside alterations 479 bd. ft., major replacements average 129 bd. ft., and maintenance and repair jobs 206 bd. ft.

Plywood use per job average 287 square feet (sq. ft.) 3/8-inch equivalent per job. Average

use per job was 135 sq. ft. per $1,000 (1970 dollars). Additions average 730 sq. ft. per job, inside alterations 224 sq. ft., outside alteration 224 sq. ft, replacement jobs 87 sq. ft., and maintenance and repair jobs 78 sq. ft. of plywood (3/8-inch equivalent).

More recent information on residential repair and remodeling is available from a telephone survey of a sample of about 20,000 of the Nation's 78 million households in 1979 (Housing Industry Dynamics, 1980). Nationally, 27.8 percent of homeowners and 12.5 percent of renters surveyed indicated that they purchased lumber and plywood in 1979. About two-fifths of the homeowners who purchased lumber and plywood used the materials for maintenance and repair. Almost one-third of the purchasing homeowners used lumber and plywood on improvements to property outside, while 18 percent used it for interior alterations or partial renovation. Nationally, dimension lumber was the predominate material purchased for all types of jobs (Table N). Plywood was used on about one-half of the jobs and lumber boards on about one-third of the projects.

A large majority of homeowners purchased and installed lumber and plywood themselves. The share of homeowner purchasing and installing ranged from 94 percent for maintenance and repairs to 86 for room additions and 77 percent for partial renovations. Contractors were involved in 23 percent of the partial renovation and 15 percent of improvements outside the home.

Table N

MATERIALS PURCHASED BY JOB TYPE

HOMEOWNERS

U.S. TOTAL

1979

Job Type	National Incidence	Dimension Lumber	Lumber Boards	Plywood Sheets
Maintenance/Repairs	12.0%	78%	38%	48%
Improvements Outside Home	8.2%	88	25	44
Partial Renovation	5.1%	85	33	45
Room Addition	2.3%	93	35	42
Replacement of Major Equipment	.6%	83	26	52
Complete Renovation	.5%	89	11	42
Other Jobs	1.0%	77	23	41

Source: Housing Industry Dynamics.

When homeowners who purchased lumber and plywood undertook a complete renovation, the predominant use of the material was for framing. Other common uses included steps/stairs/rails, paneling, and cabinets. When a partial renovation was undertaken, homeowners who purchased lumber and plywood used it primarily in the kitchen, basement, and bedroom. In more than one-third of the room addition jobs, homeowners who purchased lumber and plywood used the material to add an open porch, while one-fifth of the purchasing homeowners enclosed an existing porch. When homeowners who purchased lumber and plywood used the materials for maintenance and repairs, shelving was the predominant item constructed. In addition, 10 percent installed molding, 6 percent built furniture, and 5 percent installed flooring. When the purchasing homeowner used the material for improvements outside the home, the predominant item constructed was fencing, followed closely by a shed and decking. When the replacement of major equipment was undertaken, more than one-third of the homeowners who purchased lumber and plywood used it to replace roofing, while an additional 29 percent replaced plumbing.

The average homeowner who purchased lumber and plywood used 12 pieces of dimension lumber, 3.6 pieces of lumber boards, and 1.8 sheets of plywood. Nearly all of the lumber and plywood was purchased by the do-it-yourself homeowner. Of the different types of jobs, a majority of the

plywood was purchased by the homeowner to make improvements to property outside the home. Nearly half of all dimension lumber, one- third of all lumber boards, and two-fifths of all plywood was used in this type of job. Maintenance and repairs also consumed a significant quantity of lumber and plywood, with more than one-third of all lumber boards and one-quarter of all dimension lumber and plywood sheets used in this type of job.

When homeowners purchased dimension lumber the predominant size was 2 x 4 inches. More than one-half of all dimension lumber purchased by homeowners was this size, while more than one-quarter of the lumber boards purchased by homeowners were 1 x 6 inches. Nearly one-third of the plywood purchased by homeowners was one-half inch thick, while 1/4-inch plywood, 3/8-inch plywood, and 5/8-inch plywood each accounted for 15 percent of the plywood purchased by homeowners.

The general decline in construction residential repair and remodeling is illustrated in the following data on interior wall panel and exterior siding for the period from 1977 to 1981. Both experienced substantial declines in incidence of purchase after peaking with the general housing boom in 1979.

In 1981, more than 4.6 million of the 82 million households nationally purchased wall paneling. This is a decline of 23 percent from 1980 when nearly 6 million homeowners and renters purchased paneling. In addition to the decline in actual purchasing households there was also a

13 percent decline in the average amount of wall paneling purchased. Therefore, the state of the economy had a significant impact on the wall paneling market, causing a significant decline in demand in 1981 (Housing Industry Dynamics, 1982).

In 1981, the number of households purchasing paneling declined for the second straight year, down 35 percent from 1979 when the number of households purchasing paneling was at its highest point for the 5-year period, 1977-1981. Plywood backed panels accounted for about 70 percent of panel sales in 1981, while hardboard and particleboard accounted for 9 percent, lumber 6 percent, and other materials 15 percent.

In 1981, 2.7 million of the 82 million households nationally purchased exterior siding materials. This is a decline of 28 percent from 1980, when 3.8 million households purchased siding. However, the purchase rate data indicates that homeowners were not cutting back on the average quantity they purchased in 1981. Therefore, the economic recession had its only significant impact on the initial decision of homeowners to undertake residing jobs. Once they decided to reside, their buying behavior in terms of quantity purchased remained unchanged from 1980 (Housing Industry Dynamics, 1982).

The estimated number of purchasing households for the 5-year period were:

In 1981, the number of households purchasing siding materials declined for the second straight

year, down nearly 33 percent from 1979 when the number of households purchasing siding was at its highest point for the 5-year period 1977-1981. In 1981, wood products accounted for 24 percent of siding purchases while aluminum accounted for 30 percent, vinyl products 27 percent, and all other products 18 percent.

The estimated number of purchasing households for the 5-year period were:

Year	Actual Number of Purchasing Households	Change From Previous Year Percent
1977	6,367,000	--
1978	6,449,000	+ 1.3
1979	7,050,000	+ 9.3
1980	5,999,000	-14.9
1981	4,610,000	-23.2

The extimated number of purchasing households for the 5-year period were:

Year	Actual Number of Purchasing Households	Change From Previous Year Percent
1977	2,136,000	--
1978	2.903,000	+35.9
1979	4,033,000	+38.9
1980	3,783,000	- 6.2
1981	2,708,000	-28.4

HOUSING DESIGN AND DEVELOPMENT

The Delphi Technique, a method for systematic solicitation and collation of judgments, was used as a primary basis for assessing future housing design and development trends. The following seven design professionals, educators, private practitioners and government employees participated in this three-phase survey: Robert Loverud, Design Science International, Boston, Massachusetts; Jamie Bellalta, Notre Dame University, South Bend, Indiana; Pat Horsbrugh, Environmental Foundation International, Inc., South Bend, Indiana; Andrew Euston, U.S. Department of Housing and Urban Development, Washington, D.C.; Michael Gelick, Department of Architecture, Circle Campus, University of Chicago, Illinois; Kenton Peters, Kenton Peters & Associates, Madison, Wisconsin; and Robert Beckly, School of Architecture, University of Wisconsin-Milwaukee. In the first phase, participants were asked to list constraints to providing affordable, amenable housing to large numbers of people in this country. After listing the constraints, each of the participants described innovative dwelling designs and/or construction techniques to overcome the constraints. These constraints and design solutions were then listed on a matrix that became an instrument by which each participant could evaluate the total response of the group. This matrix was left open-ended to permit participants to expand on their list of constraints and

design solutions. The matrices were analyzed and the innovative dwelling designs and construction techniques were prioritized for the highest ranking constraints. For the third and final phase of the Delphi Technique the participants gathered in Madison, Wisconsin to critique the matrix analysis. The results of this survey are given below in the following format: constraints, beginning with the highest precedence, are listed individually. Innovative dwelling design solutions and construction techniques offered as solutions are discussed under each constraint with supplemental information derived from a search of current research and professional literature.

Cost of Financing

The financial aspects of the housing market today exert the most obvious restraints on providing affordable, amenable housing to large numbers of people. In 1975 the median-priced new house sold for $40,000; purchasing it with 20 percent down and 8 percent interest, cost the buyer $247 per month in mortgage payments. By 1982, the median-priced new house sold for $70,000, interest rates soared to 16.5 percent and as a result, a buyer making 20 percent down payment would have monthly mortgage payments of $783. The buyer's monthly payment rose 216 percent and during the same period median household income rose only 61 percent (Turner 1982). It is obvious that this major obstacle cannot be overcome by applying a number of innovative design or construction techniques. Solving

this problem will take the concerted effort of home building and financial agencies, developers, builders and design professionals using every available technology, regardless of its origin or the length of time it may have been available.

Land-Cost of Acquisition, Development and Impact

Imaginative siting and clustering, rehabilitation and retrofiting of existing buildings and urban infill are the design solutions proposed to overcome this constraint. In the late 1940s the suburban housing boom started, but it was in the 1950s that the mass-built single-family detached house really dominated the housing market. This housing form moved into the 1960s with new concepts and refinements. The next decade, the 1970s saw trends which will affect our housing choices for the future. The rate of inflation rose dramatically and the seemly unending flow of cheap energy came to an end. During the last 10 years we have developed roughly 1.2 million acres of land per year. If this rate of development continues we will need 24 million acres for development by the year 2000.

Continuation of this trend will depend, in part, upon the extent to which increasing housing and energy costs will motivate more compact development. On undeveloped land every possible effort should be made to site housing units in clusters around cul-de-sacs or common spaces. This method of site planning reduces the quantity of land consumed and saves development

cost by significantly reducing the length of streets and utility lines to service the units. Energy will also be conserved since less petroleum-based raw materials will be used and if well planned, cluster housing developments will encourage alternative transportation modes such as walking or biking to school and shopping.

In developed areas, rehabilitation and retrofitting of existing buildings and urban infill present a logical solution to the problem of land cost. Both design solutions take advantage of the existing infrastructure and consequently, in most cases, reduce the cost of development. The growing appeal of development opportunities in urban areas is being reinforced by obstacles that developers are beginning to encounter in their traditional suburban locations. Municipalities such as Salem, Oregon, Spokane, Washington and Riverside County, California have begun to define their "urban service area" and are reluctant, or refuse, to extend public services outside of these areas (Starr 1980). The inability to obtain public services, the increasing subdivision fees and rapidly escalating land cost are all impacting traditional development patterns.

Codes Which Set Abnormally High Minimum Standards

It is impossible to encourage innovations in the housing industry if building and zoning codes do not allow for them because localities have difficulty maintaining up-to-date code requirements. Model code groups annually

approve and forward to local governments hundreds of revisions that the local governments have neither the time nor the staff to review, approve and incorporate. Many local governments that have not adopted model codes have retained outdated local codes that require the use of certain materials or processes. This not only precludes the use of innovations but also increases the cost of homebuilding. To resolve this problem the creation of a national computer-aided building industry information system is recommended. This system could contain information from basic material research to production techniques and evaluation of previous applications. Such a system would reduce the time lapse for approval of new techniques by both the model code groups and local government agencies. In addition to resolving problems with code up-dating, this computer-aided information system would also alleviate the homebuilder's reluctance to use innovative technology because they do not wish to risk poor performance based on insufficient technical information on how to use materials or systems. Information on the materials and technology being used in commercial construction that would readily adapt to residential construction would also be provided.

Labor Cost and Union Regulations

To reduce the cost of labor it is necessary to reduce the time and increase the efficiency of assembling housing units. This task has been accomplished to some degree by the factory-built

housing industry, but the effects on the overall housing market have been minimal with the exception of the increasing number of mobile home units, or manufactured housing units, which have increased by 84 percent, from 2.1 million units in 1970 to 3.8 million units in 1980. This increase illustrates a shift in government and consumer perception of mobile homes. Today mobile homes on the owners land are now considered real property, not personal property, and are financed and taxed as real estate. Zoning restrictions have eased and a new federally imposed building code had made mobile homes a better constructed product. Most important, more and more mobile homes look like site-built homes inside and out. With these changes, the mobile home manufacturers have begun to assume the role of providing low-price housing.

Price is not a big benefit of building with factory-made panels. Some packages do cater to low-end markets but they are competitive with, not cheaper than, comparable stick-built housing. On-site labor is reduced by factory-made panels but not eliminated. The on-site labor that is left involves the more costly part of the house - the mechanicals, for example, and the finishing jobs. Most panel manufacturers are not geared to mass-producing affordable housing.

To create a significant reduction in the cost of housing in this country would require large investments in research and retooling of large industries, such

as the automotive industry, to develop a house mass-produced on an assembly line. Misawa Homes Company in Japan has produced such a house (Business Week 1982). Misawa's "House 55" can be rough-assembled on a construction site in two hours, far less than the three or four days required to erect a prefabricated house. Each of Misawa's houses are composed of 10 capsules bolted together on the site. The capsules are composed of a new type of ceramic made of low cost silica sand and limestone, creating walls that are soundproof and resistant to intense heat and earthquake. On sale in Japan since January, these houses cost $30,000 to $100,000, about 20% less than prefabricated houses. In addition to the large investment of time and money needed to produce a similar housing unit in this country, it would be necessary to overcome the American attitude that prefabricated homes are cheap and tacky.

Socio-Cultural Demands

The overwhelming majority of Americans identify with the pursuit of the American dream. A key element of that dream is home ownership, which for the past 35 years has been defined as proprietorship of a single family detached house owned in fee simple. For most Americans this dream can no longer become a reality. As stated previously, the cost of home ownership in our present economy has spiraled far above the increase in family income. The only method of aligning the socio-cultural demand with the realities of the market

is through public education. The American public must realize the economic and environmental cost of land and development of that land. They must realize that we must conserve our natural resources and to do this, must accept alternate forms of shelter. We must expect smaller lots, higher densities and less energy consuming structures. The amenities that existed during the last 35 years cannot be renewed through innovative designs or construction technology.

"HMX-1" is the name of an experimental house created by a team of experts for the National Association of Home Builders 1982 Convention. This home contained less than 1000 square feet of space, for the non-traditional market, at a price estimated at $34.10 per square foot in the southern California market. The materials and techniques used to produce this house are standard manufactured materials and existing construction methods (Gerardi 1982). The small spaces contained in this house were designed to appear large. According to Walter Wagner, Jr., editor of Architectural Record, these spaces were made to seem large "by all those techniques of opening up space that architects have known for years." The HMX-1 is a reality. It was built with today's design and technology. Why then can we not produce similar units to meet our housing demands at affordable prices? The answer to this question is very simple: the builder did not have to contend with high land cost, codes which may have prohibited him from constructing a unit with minimal square foot-

age, delivery of utilities, lack of technical information, and doubts of market acceptance. It took a great deal more than innovative design and technology for this country to put a man on the moon and it will take similar government support coupled with innovative design and technology to provide affordable, amenable housing for large numbers of people in this country.

Paper Building Material Scenario

Alternative construction materials may be available in the near future which could alter wood consumption dramatically in housing. An example of an innovation which could reduce the amount of standing timber used for housing is currently being tested at the United States Forest Products Laboratory in Madison, Wisconsin. This new form of housing is constructed with double-walled corrugated fiberboard which can be made from recycled wood and paper products. Dr. John Koning of the Forest Products Laboratory postulates that "durable, structurally sound" homes of this type could be on the market within five-six years if research being conducted to improve the moisture resistance of the product is successful.

Corrugated fiberboard housing could be an inexpensive housing type for three reasons. An environmental incentive as well as a financial one, it can be made from recycled paper waste. With the development of more efficient recycling systems, fiberboard could become much cheaper than conventional construction materials (lumber, plywood, and various other board products). The usual transportation costs involved in the construction industry can be reduced since recycled materials are closer to markets than standing timber resources and lighter and more compact than conventional construction materials. Corrugated fiberboard homes could be based on simple construction principles; therefore they could be erected quickly and

easily.

A study by the University of Wisconsin-Madison Environmental Awareness Center (Huber 1982) has shown that each year enough recycled paper is available in the Midwest Circle City Area (see Appendix) to construct all housing starts initiated during that year (Table O). The amount of paper products recycled and available for future use in Circle City is 562,105 tons. According to Dr. John Koning, if each 1600 square foot (floor area) double-walled corrugated fiberboard home uses "approximately 1 ton" of recycled paper waste, then 562,105 corrugated fiberboard homes could be constructed from the paper waste in Circle City in one year. Only 35,106 homes were built in the Circle City region in the period from March 1981 to March 1982. This means that there were sufficient recycled resources to build the entire new residential construction in the Circle City region. In fact, export of double-walled corrugated fiberboard from the Circle City region could even occur. This is true even when we recognize that nationally, only 26.2% of paper is recycled today.

Obviously, a housing form of this type would reduce the total amount of standing timber needed for housing. This wood could be utilized for other needs. In terms of efficiency of wood use, ". . . a discarded forest product retrieved as wood or wood fiber can be recycled to a higher, the same, or to a lower order of use" (Auchter 1971). The higher the order of use that is maintained, the more efficient and long-

Table O.

Recycled Paper Data

1.	Total paper trash thrown away (amount/capita/day)		.7 lbs.
2.	Population of Circle City in 1980	X	16,794,151
3.	Paper trash thrown away in Circle City (amount/capita/day)		11,755,913 lbs.
4.	National average recycled (best available data on recycling existing)	X	26.2%
5.	Amount recycled in Circle City/day		3,080,049.2 lbs.
6.	Number of days in 1981	X	365
7.	Paper trash recycled in Circle City in 1981		1,124,210,000 lbs.
8.	Convert pounds to tons		=562,105 tons

lasting the material use. With double-walled corrugated fiberboard, housing can be derived from lower order paper and board use. Thus, as a viable future alternative, corrugated fiberboard housing improves wood utilization and the efficiency of wood use. Paper housing units (made from recycled trash) could be any color, texture or pattern. The walls could be layered for complete insulation, fireproofed, and engineered to be structurally sound.

Perhaps recycled trash will offer a most attractive low cost housing unit.

CHARACTERISTICS OF THE RESIDENTIAL CONSTRUCTION INDUSTRY

The residential construction industry involves a large number of actors. There are individuals acting in their own behalf; firms that have widely variable structural characteristics; and industries whose activities range from building homes to supplying specialty items to the producers. Ventre (1980) describes the system as diverse, dispersed, detached, and discontinuous. On page 311 he states:

> It is diverse: just over 70% of the 800,000 construction establishments are sub-contracting units engaged in highly specialized work. The range of specialists is sweeping: besides the well-known specialties such as plumbing, electrical, and sheet metal work are the highly specialized trades such as underground wire contractors, contractors whose sole work is applying insulation to piping and mechanical appertenances installed by still other specialty contractors. In all, residential construction involves about 75 specialties organized by 17 craft unions.
>
> The construction industry is also broadly dispersed. Whereas other durable goods industries have become identified with specific cities or urban regions - an economic geographer associates semi-conductors with the San Francisco peninsula's "Silicon Valley" or Tabasco production with Avery Island - there is no such geographical concentration in the construction industry. Rather, construction firms are distributed across the nation as the population is distributed, the better to serve local need; fewer than 10% of construction firms work beyond the borders of their own state. And housebuilding is even more spatially limited.
>
> The construction enterprises are detached in several senses: (1) work moves from site to site, job to job; (2) the combination of possible sub-contractual arrangements among the 10-18 specialty firms likely to be engaged on any single job is rarely ever repeated, making systems-oriented management difficult. This is less true of residential construction, for homebuilders tend to use the same team over several years; and (3) commercial and insti-

> tutional builders are detached from their sources of supply of building materials, shifting among vendors of highly differentiated products as consumer tastes and architectural fashions change.
>
> The construction industry, and particularly housebuilding, is a highly discontinuous enterprise. The seasonal and annual fluctuations of volume are well known. Finally, the discontinuity of construction work is noticeable even from day to day: the vagaries of weather can undercut close coordination of a building team of specialty contractors and material suppliers.

These characteristics are variously praised and damned, depending on the industrial and economic models through which the construction industry is viewed. Homebuilding has been described as one of the few folk traditions left in contemporary industrialized society. In numerous other sources it has been characterized as a "backward industry" (Schon 1967). It has also been praised as a model for the post-industrial era, due to its regionalization, many actors, ease of entry and exit, and low level of capitalization.

Part of the reason why the industry exhibits these characteristics is its adaptation to wide swings in annual housing start rates. Peak and trough amplitudes as great as 30 to 40% occurred three times between 1950 and 1962 (Maisel 1963). Others have shown similar peaks and troughs between 1953 and 1972. In the past decade, fluctuations have become even more radical. Because of the fluctuating characteristics of the housing industry, observers such as Ventre (1980) claim that the housing industry must be viewed _sui generis_--not with the criteria of conventional industrial eco-

nomics:

> Whereas the construction industry's smallness of size, primary reliance on manual skills, and high rate of entry-exit may be viewed as shortcomings and signals of dysfunction among manufacturing entities, these qualities are, in fact, the very genius of the adoptive construction industry's response to social and economic forces. . .

There are basically four types of homebuilders: (1) merchant builders who use their own designs and build on their own land, (2) custom builders who build on contract, (3) manufactured homebuilders who pre-assemble housing components and transport them to the building site, and (4) mobile home manufacturers (Kaiser 1973).

A survey conducted by the National Association of Home Builders (NAHB) found that in 1976 three-fifths of their members were merchant builders of single family homes and one-fourth custom home builders. The housing market is dominated by small independent producers. Two-thirds of those building single family homes built less than 25 units per year, while one in ten built more than 100 units per year. The 1976 survey found that those builders constructing less than 25 units per year had an average of six full-time workers.

A major characteristic of the housing industry is its localized nature. In the same survey, NAHB found that three-fourths of its members who build single family homes and two-thirds of the multi-family builders operate in only one market area.

Dunlop and Mills (1968) describe the individual involved in homebuilding as mobile among various geographical locations

and types of construction. A large number of producers, both builders and subcontractors, are involved in housing construction. NAHB reports that three-fifths of its builder members subcontracted 75 percent or more of their workload, only one in ten subcontracted less than 25 percent.

Building construction, unlike most other industrial enterprises, does not invest heavily in fixed equipment. Instead, investments are made in financial capital and skills of the workforce (Ventre 1980). Dunlop and Mills (1968) estimated that 80 percent of all construction workers belonged to a union, but that homebuilding was well below that figure. The 1976 NAHB survey of member building firms found less than one in ten employing unionized workers. The survey also found that the most prevalent unions among unionized firms were carpenters, laborers, electricians, bricklayers, plumbers, painters, masons and roofers.

Materials suppliers represent an important segment of the building industry. Ventre (1980) divides manufacturers into five groups: (1) lumber and wood products, (2) plumbing and structural metal products, (3) electrical lights and wiring equipment, (4) stone and clay products, and (5) paint and allied products. Each of these manufacturers provide at least 40 percent of their inventory to the construction industry. The interrelationships between builder and supplier are many and fluid. Small builders rely primarily on local retail outlets, whereas large firms may buy directly from

the manufacturer (Kaiser 1973). The majority of small supply outlets are lumberyards with the remainder divided up among specialty shops. Small builders are dependent upon local outlets and use those types of materials that are most readily available or that they can persuade the outlet to stock. Retail outlets provide services as well. If the builder requires technical assistance in the course of a project or preparation of materials, the supplier can provide it (Kaiser 1973; Perkins 1982). These outlets are also where new innovations are usually introduced. The research and development needs of the building industry are met primarily by the suppliers of building products. The success of new technology relies significantly on the suppliers acceptance and promotion of new products. The typical retail outlet is locally owned and operated. Conversely, the manufacturers of building materials are more centralized. Materials like lumber, plywood, doors, roofing materials, etc., come from a smaller number of larger firms (Perkins 1982).

The residential construction industry has exhibited significant changes over the last three decades. The 1950s and 1960s were a time of relative stability, with an average 1.5 million housing starts annually. Beginning in 1971, the United States government began subsidizing housing and the number of units built increased dramatically to 2.1 million. This level remained relatively constant through the 1970s and in 1978 2.0 million

starts were reported. This excludes the years 1974-76 which averaged 1.4 million starts per year. In 1979, high inflation combined with high unemployment created a downward spiral that in 1981 resulted in 1.1 million starts.

The homebuilding industry is in a period of transition. Inflation rates, energy costs, resource costs, mortgage rates and other characteristics have changed since 1979. It has been suggested that once the current recession lifts, the housing industry will start on a new course fundamentally different from the present (Rippe 1982).

The ability of the residential construction industry to innovate has been the subject of a broad range of commentary. In 1967, Charles Abrams (1967) reported that:

> Of all the commodities that have been touched by the industrial revolution, the house has remained the most impervious to change.

Christopher Sims (1968) in his work for the President's Committee on Urban Housing, put forth the opposite view:

> The Building, Civil Engineering, and Public Works Committee of the International Labor Organization suggested in a 1964 publication that the construction industry had in recent years undergone a technological explosion.

Most judgments of innovation in the housing industry have been conjectural; little empirical work has been done. Ventre (1980) characterizes many of these judgments as the observations of "sidewalk superintendents" who confuse a relatively unchanging housing style with a lack of technological innovation. He further asserts that when empirical

analysis is conducted of technological change in the housing industry, conventional measures of technological change in industry are used. These, he claims, mislead analysts of the building industry, resulting in a continuing popular and academic misreading of the industry. His own empirical inter-industry comparisons of technological diffusion shows the building industry to rate favorably with others (p. 318):

> The major significant result is the denial of the technological lethargy of the building industry and the agencies which regulate it.

BARRIERS TO INNOVATION IN THE HOUSING INDUSTRY

This section of the report discusses barriers to innovation in housing, and resultant implications for wood use. In order to avoid oversimplification of the housing innovation process, this discussion will occur in the larger context of the overall factors which influence change in the building industry, whether they be barriers or facilitators. As Ventre (1980) points out, the building industry is far too complex for a limited number of actors or factors to significantly affect the change process:

> The building industry is an intricate combination of hundreds of thousands of actors, both individual and institution, private and public and voluntary, some in temporary alliance, ad hoc coalitions maintained only for the duration of a single building project. No single actor asserts enough control over enough of the building process to be decisive. A popular characterization of the reluctance of the building industry to show more responsiveness to technological change has been the identification of "obstacles" to innovation. Under this "obstacles" view, two or three of the hundreds of actors are singled out for indictment as progress retarders. Obsolete building codes and restrictive union practices are more frequently indicted.

Of the factors affecting building innovation, the following represents those most frequently cited in interviews and the literature.

Standards and Codes for Materials and Methods

Public and private management of much of the building innovation process occurs through a broad range of federal, state and local regulatory agencies, associations of regulators, and

public and private testing and standards-setting institutions.

New building materials and methods are tested using in-house private laboratories and independent private laboratories. To support the credibility of laboratory tests, both the American Association for Laboratory Accreditation (AALA) and the National Voluntary Laboratory Accreditation Program (NVLAP), a part of the National Bureau of Standards, will accredit laboratories that are competent to conduct appropriate specific tests. The President's Commission on Housing Report (1982) contains a recommendation for an effective national laboratory accreditation system, inferring that the current accreditation process is not as integrated into the overall materials certification process as it could be.

Based on appropriate laboratory tests, product standards are set. Associations of individual materials producers, such as the American Plywood Association, set industry standards for product composition, performance and quality. Most building standards are developed through processes developed by the American Society of Testing Materials (ASTM) or the American National Standards Institute (ANSI), both of which are voluntary private sector associations. Materials and construction standards developed through ASTM and ANSI processes represent the work of over 100,000 individuals in hundreds of technical committees. These committees follow a consensus process which seeks to ensure balanced evaluation by inviting

participation and challenge. Committee memberships are drawn from material producers, designers, engineers and others familiar with technical issues. Committees attempt to consider a variety of criteria including health, safety, durability, and ease of maintenance. Most observers of this approach generally believe that it fosters the acceptance of changes in the housing industry because it results in reliable product standards set on a broad base of inquiry.

After standards are developed, they are reviewed by one of three model-code organizations to confirm that the standards meet appropriate concerns and are enforceable.

Model codes include building, fire, safety, plumbing, electrical and mechanical systems codes. Unlike the ASTM consensus process, the model codes are issued by an association of building code officials. Non-voting committees include professionals from other disciplines.

Each of the three building code organizations issue a model code. The Building Official and Code Administrators, Inc. (BOCA) tends to prevail in the East and North Central States; the International Conference of Building Officials (ICBO) in the Western States; and the Southern Building Code Congress International (SBCCI) in the South. An umbrella group of these three groups, the Council of American Building Officials (CABO), publishes the CABO One and Two Family Dwelling Code. The 1970's saw significant progress in the three groups in harmonizing their model code re-

quirements and unifying code enforcement. The model codes covering housing construction include performance provisions that allow flexibility in meeting requirements, in addition to prescriptive standards.

Model codes are used by many state and local governments as the basis for their codes. A standard or code has the force of law only when officially adopted by a government body. To date, 25 states have adopted statewide building codes. Fourteen of these are "minimum" codes that permit localities to set more (but not less) restrictive requirements. Three states have "maximum" codes that include standards that localities may not exceed in their codes. The remaining eight states have mandatory uniform statewide codes. The further imposition of statewide codes, reinforced by professional code administration, could significantly reduce cost and foster innovation by giving developers advanced knowledge of a clear set of standards that apply to all localities. This would enable builders and suppliers to use a wider range of tested and certified materials and methods to serve a statewide market.

The Federal role in building materials and construction standards dates back to the National Housing Act of 1934 which called for the development of Minimum Property Standards (MPS) as part of FHA's insurance program to ensure the quality of federally-insured housing amidst an uneven quality of state and local codes. Over the years, the Federal government has increasingly used

construction standards.

Much of the credit for the growth of the mobile home industry in the past decade is given to the existence of the Federal Mobile Home Construction and Safety Act of 1974. The only nationally-imposed code applying to the housing construction industry, it has ensured uniform quality and has saved manufacturers from having to adapt production lines to meet the standards of thousands of local building codes. The growth of the mobile home industry results in a lower use of wood per unit because mobile homes are more plastics-intensive, are allowed to use less wood due to construction standards, and are generally smaller than other alternative housing units.

Overall judgments relating to building codes as barriers to innovation fall into two groups--those who focus attention on how far the codes have come, and those who focus on how far they have yet to go. In the former group are persons such as 1980-81 BOCA President Wilbur Lind who writes:

> When we consider what is permitted today in the area of construction technology--and which was absolutely in some cases outlawed at the end of World War II--I believe anyone, in all fairness, would have to acknowledge that the building codes have indeed changed. They have done more to facilitate new materials and innovations than any other sector of the construction industry. (Lind 1981)

In the latter group are judgments such as those recently expressed by the President's Commission on Housing. While recognizing advances made by testing and code organizations, the Commission stated that the

building standards and code process could be improved by creating an effective national laboratory accreditation system, removing code requirements relating solely to aesthetics and marketability, adopting model codes with minimal amendment, upgrading the professionalism of code officials, expanding membership of model-code groups, improving coordination of building and fire safety codes, and adopting appropriate rehabilitation guidelines.

Presumably, these improvements would facilitate the overall innovation process in the housing industry. The improvement that appears to offer the most promise for facilitating innovation is the enactment of additional mandated state building codes.

Wood Use Innovations and Materials Standards

So far this analysis provides few clues as to whether wood use will grow, decline, or otherwise change as a result of building standards and codes. Some insight into the relationship between wood use innovations and standards and codes can be gained by reviewing primary wood-related innovations introduced in recent years. These include wood truss systems, reconstituted wood products, the all-weather wood foundation, a set of incremental wood framing practices, integrated structural engineering and design, and new testing procedures and grading standards.

Light-weight wood trusses are among the most highly engineered components used in house construction today. Primary truss

systems include roof trusses, floor trusses, and the recently introduced truss frame system. (Milwaukee Sentinel 1982). Roof trusses are widely accepted and used today, and floor trusses are increasing in popularity. A 1981 survey of U.S. building component manufacturers reported that 95% make roof trusses and 52% make floor trusses. A similar survey conducted in 1979 revealed that 85% made roof trusses and 48% made floor trusses (AIH/SBN 1981). Use of roof and floor trusses results in significant wood savings because they can be spaced 24" on center, use smaller-dimension lumber (allowing shorter forest harvest cycles), and are engineered to use a minimum amount of wood. The truss frame system integrates floor, roof, and wall pieces into overall framing pieces that are placed on foundations 24" on center. Developed by the U.S. Forest Products Lab in Madison, Wisconsin in the late 1970's, the system has been used to build over 1,000 homes to date.

Introduced in the 1950's, the roof truss began to gain rapid acceptance in the late 1960's. Floor trusses have come into general use in the last 5 to 10 years, replacing the wider widths of dimension lumber. Because of the engineering needs of residential roofs, roof trusses are more of a "natural" than are floor trusses, which partially accounts for their wider use. A significant advantage of the truss systems is that they can be constructed using narrow width, readily available, existing dimension lumber. In addition,

their construction requires less complex technology and capital investments than other wood use innovations. None of the industry association representatives interviewed mentioned codes or standards as impediments to the adoption of truss systems.

Reconstituted wood panel products are beginning to displace traditional plywood uses in floor, wall and roof construction. Plywood had previously displaced board sheathing. Plywood itself has undergone significant changes. When it first entered the market only Douglas fir veneers were used. Today about 70 softwood tree species are used. However, resource supply and cost problems have fostered the search for alternatives. These alternatives include structural particle board, composite panels with outside veneers like plywood, and two non-veneered panels: flakeboard (also called waferboard) and oriented strand board. Both flakeboard and oriented strand board can be made of aspen, an underutilized species. Hardwood species, such as red oak, are also now being used in reconstituted panel products, allowing further use of underutilized wood species. The ability to utilize new species allows regional production away from the South and far West, thus reducing transportation costs. Cost is a primary advantage of reconstituted panels. For example, aspen roundwood costs about $28 to $30 per 1,000 square feet of reconstituted product compared to raw material costs of $85 to $95 for plywood. Currently the non-veneered products account for an estimated 5%

to 10% of the structural panel market (Housing 1982a). In observing the rate of plant expansions and new plant construction to produce reconstituted panels occurring in Canada and the U.S., one industry trade journal termed the phenomenon "nearly explosive." (AIH/SBN 1980)

Flakeboard has been approved for specific applications by the three model code organizations as well as FHA, HUD and USDA. Other similar products are currently being processed through approval processes. Housing industry observers feel that the building standards and codes have imposed no significant impediment to the increased use of reconstituted wood products, and forecast a gradual, significant shift toward reconstituted wood products in the future.

The all weather wood foundation, constructed of preservative pressure-treated studs and plywood is another major wood-related innovation that has occurred in recent years. The most frequently mentioned advantages of this system include cost savings, fewer trades to coordinate, suitability for cold weather construction and prefabrication, elimination of basement leakage (source of the builder's most frequent call-back), ease of wiring, plumbing, window and door installation, and ability to insulate. As plywood markets are displaced by reconstituted panel products, all weather wood foundations appear to be a good growth market for plywood. To date an estimated 100,000 homes have been built using the technique in the U.S. and Canada. The

system has received HUD and model code organization approvals. However, general acceptance of this system has come only after a decade-long battle with the masonry industry. Because of the major threat to its market, the masonry industry has raised continuous questions over the safety of wood treatment chemicals, the ability of preservative treatment chemicals to adequately and dependably penetrate wood, and other issues. Characterizations by industry observers of the rate of adoption of the all weather wood foundation range from "very good" to "spotty." Because the masonry industry has apparently lost its battle at the national level, it has focused more recent efforts at the local level. If more states had state-mandated building codes based on national models, these localized efforts would probably not be undertaken. However, there is no empirical data to suggest that the masonry industry's fight against the all weather wood foundation has significantly retarded its adoption.

In recent years, a set of incremental wood framing techniques has been introduced that in the aggregate result in significant wood savings. These changes have resulted from engineering analyses of traditional framing techniques, and the elimination or alteration of materials not structurally necessary. Some of these techniques include the use of 2" x 3" studs in non-load bearing partitions, single-layer plywood flooring, reduction or elimination of sill plates and band joists, plywood box headers, and changes in exterior wall

corners and partition posts. These techniques, if not specifically allowed under the prescriptive standards of model codes, are generally allowed by the performances sections of codes. Industry observers did not mention codes as impediments to these practices. The most oft-mentioned impediment was the reluctance on the part of builders (especially small scale builders) to diverge from traditional construction practices.

By integrating these and other framing techniques into integrated structural engineering and design concepts, further efficiencies have been gained. For example, "mod 24" or home construction on 24-inch or 4-foot increments produces significant savings in materials and labor. In one example, using 1980 costs, a 2,000 square foot home, with rafters and studs 24 inches on center instead of 16, was shown to save $2,000 to $3,000. This included a $300-$400 lumber saving plus a broad range of attendant labor and construction savings (Builder 1980d). The Optimum Value Engineered (OVE) building system developed by the National Association of Home Builders Research Foundation includes framing members spaced 24" on center and a variety of wood-related cost-saving techniques, resulting in a 12 percent construction cost saving. Of that total, 69% was in materials, 31% was in labor. In constructing an OVE prototype house, most building code approvals were obtained under the performance provisions of the local prevailing BOCA code on the basis of engineering and

test results (HUD 1978). Industry observers feel that the primary builders who are implementing these integrated engineering and design concepts are larger-scale operators and those producing factory-built modular or panelized units. Again, the inertia of the traditional building techniques practiced by the smaller-scale builders who dominate the industry appears to be the primary impediment to innovation. This does not mean, however, that the answer to housing innovation is the consolidation of the building industry. The pitfalls of consolidation may well be more numerous than the advantages. A demonstration house recently completed near Madison, Wisconsin demonstrates nearly all of the wood use innovations discussed above. This house won a 1981 HUD design award. Such demonstrations may be an affective method of informing smaller-scale builders of cost-saving innovations.

New testing procedures and grading standards represent additional innovations that promise further efficiencies in wood use. While most observers feel that the primary technical innovations that will be made in this current era have already been developed, they also see a new threshold of knowledge of wood capabilities coming from primary wood research currently underway. In the past, structural standards have over compensated for the limited knowledge of wood's structural properties. More refined knowledge of these properties, along with a better understanding of component performance, will allow the "fine tuning" of standards to more

accurately reflect material property requirements. This is projected to result in significant wood efficiencies and consequent affordable housing.

Labor Unionization and Licensing

The licensing and unionization of construction crafts persons is another factor related to building innovation and cost. Licensing procedures are imposed by states and local governments to ensure that work is done by qualified people. However, studies claim that some licensing laws create barriers to entry, impose unnecessary construction costs, and restrict interstate mobility of workers. Construction crafts licensing has little effect on wood use in that most licensing requirements are focused on electricians and plumbers.

The impact of unionized labor on housing innovation is an oft-mentioned and probably overstated barrier. First of all, the use of unionized labor in housing construction is not large. In a survey conducted of the building industry by the National Association of Home Builders and published in 1979, only 8.1 percent of the builders indicated that some of their crafts are unionized (NAHB 1979). Furthermore, specific cases of organized labor's resistance to innovation reveal that wide and rapid diffusion of technological changes occur despite determined opposition. As Ventre (1980) points out, ". . . unions may be vocal resistors, but they do not always or even often prevail."

Zoning

Local zoning codes are an important area of concern related to wood use, because they are used to regulate housing type, size, placement and density. State enabling legislation and case law have given municipalities broad regulatory authority through zoning. Zoning is used to protect residential neighborhoods from other uses, control density and its impact on public services, encourage appropriate commercial and industrial development, preserve natural resources, ensure overall development consistent with long-range planning, and implement other objectives.

However, zoning has also come to be used for less laudable purposes. By the late 1960's exclusionary zoning had become commonplace. Imposed through large-lot size requirements, exclusion of multiple dwellings, minimum dwelling size requirements, and exclusion of mobile homes, zoning has become widely used to limit residential development to single family homes on large lots. This has restricted supply and imposed greater costs and locational constraints. These abuses were highlighted in the 1968 Douglas Commission and Kaiser Committee reports. In suggesting solutions, the Douglas Commission recommended greater centralization of land use regulatory authority, reduction in incentives for fiscal and exclusionary zoning, fairer allocation of land use costs between government and developer, and larger scale development. The Kaiser Commission further recommended that the

Federal government pre-empt local zoning and other land use regulations in controlling Federal construction projects and low income housing development. It favored state review of local zoning ordinances to ensure that they did not interfere with satisfying the housing needs of metropolitan areas.

In the fourteen years since the issuance of these reports, little has been done to eliminate these problems. At the same time, energy costs, resource scarcities, capital costs and the changing nature of the household have all emerged as critical reasons why reforms are all the more necessary today.

The per capita use of land for urban uses doubled from .2 acres to .4 acres between 1950 and 1970 (Houstoun 1981). The average new house built in 1979 had almost twice as many square feet of living space (and materials) as the average new house built in 1950 (President's Commission 1982). Several observers feel that the single family home as we now know it is a short-lived phenomenon based on cheap capital, energy, land and materials (Stokes 1982). Home sizes are already beginning to decline. The National Association of Home Builders notes that from 1978 to 1981, the median size of a new single-family home decreased 6.5% to 1,500 square feet (Maersch 1982). In addition, home dwellers need less space. Formation of single-person and childless couple households is occurring significantly faster than households with children. Also, the overall population is getting older and

the resulting demand will be for smaller living units. The median age of the population is projected to increase from 30.2 in 1980 to 35.5 in 2000 (Housing 1982b).

If current trends continue to force down house size and increase densities, the amount of wood used per dwelling unit will probably decline more due to this single factor than to any other area of change in the housing industry. The housing industry could adapt relatively easily to significant reductions in housing size and density because design alternatives and housing technology and construction skills are readily available and transferable.

In already-developed areas, opportunities exist for infilling vacant land with a range of development options from townhouses to high density condominiums. Large nonresidential structures can be converted to residential uses. The changes are already taking place to a significant degree. The largest potential for new housing in developed areas lies in the creation of "accessory" apartments in existing housing units. According to one estimate, about 300,000 rental units are being created annually inside single family homes, with a potential of as many as nine million units, far more than the total rental-unit production for the last decade (Wall Street Journal 1981). Conversions of existing spaces are far more cost-effective than the creation of new units. Officials in Plainfield, New Jersey, which has a model program designed to help older home owners convert,

estimate average conversion costs to be about $10,000 per unit (Hare 1981).

In most communities, accessory apartments are not currently legal under the local zoning code. Resistance to legalizing them is often based on the view that single family conversions are the beginning of a change in the single family character of a neighborhood. On the other hand, for home owners who have created illegal units, making them legal means higher assessments and the risk of being caught if rental income is not reported on tax returns. The overall effect of zoning on the creation of accessory apartments is unclear, as one observer points out:

> It's clear that simply legalizing accessory apartments will not necessarily result in the creation of large numbers of them. On the other hand, prohibiting them may not do much to keep them from spreading (Hare 1981).

If costs of alternative housing choices continue to rise, accessory apartments will probably continue to grow in popularity. The use of wood in the apartment conversion process will be far less than in new construction because of a low need for new supporting walls, rafters, joists and exterior sheathing. The next evolutionary step after accessory apartments in the suburban infill process is additions onto existing dwellings. These would utilize a higher proportion of wood and be more comparable to new construction.

In developing urban fringe areas, major economies in materials use can be achieved by

building more down-sized single family homes, attached houses (generally duplexes to four-plexes), townhouses, and walk-up apartments. The use of these housing types would be part of an overall effort at reducing housing costs and thus would involve techniques including cluster developments, small lots, zero lot lines and other methods for conserving land and infrastructure. As mentioned, the skills and technologies for making these changes are fairly readily available. Economic forces will create the demand for them. Local zoning codes will provide the forum for countervailing social, economic and cultural values to come together and determine how and when they will come about.

The stereotypical "environmentalist vs. developer" conflict will probably not act as a significant future barrier to innovation in housing types. In fact, environmental groups and housing providers are beginning to identify the common ground between cost-effective housing provision and environmental goals. For example, in January, 1982, the National Association of Home Builders and the Sierra Club issued a joint statement on development principles that both groups agreed to. The following is a partial excerpt from that statement:

> America's demand for housing and the pressure on natural resources continues. To promote decent, affordable housing in a sound environment, the National Association of Home Builders and the Sierra Club will encourage:
>
> 1. Building of needed housing as "infill" on appropriate vacant land within urban and adjacent suburban areas at densities sufficient to encourage cost-effective

transit service.

2. Rehabilitation of older usable housing.

3. Compatible mixes of housing, commerce and industry.

4. Energy-efficient building design and water conservation measures.

5. Development of adequate cost-effective transit service.

6. Governmental acquisition, with fair and equitable compensation for parks and open spaces. . .

. . . We urge state and local governments, after assuring this cooperation, to improve permit processes by specifying development requirements in advance, by coordinating review times when projects are proposed, and by eliminating unnecessary delays and duplicative reviews.

We further encourage local governments to adopt incentives and development standards that promote more efficient land use through higher densities and through cost-effective site design for infill areas (Sierra 1982).

This type of joint recognition of desired future development patterns needs to manifest itself at the local level of government, where the legacy of large-lot and exlusionary zoning is still very much alive.

Unlike building codes, the zoning process has no comparable national model ordinance and standard-setting organizations to improve the system. The balkanization of local governmental units creates a significant incentive to disregard regional housing needs. Also, many of the fiscal incentives that fostered the movement toward large-lot and exclusionary zoning have become even more forceful. Owners of existing housing, worried about static or declining home values, are resisting the placement of affordable housing near them, fearful of the possibility that these new houses will further reduce their own home values.

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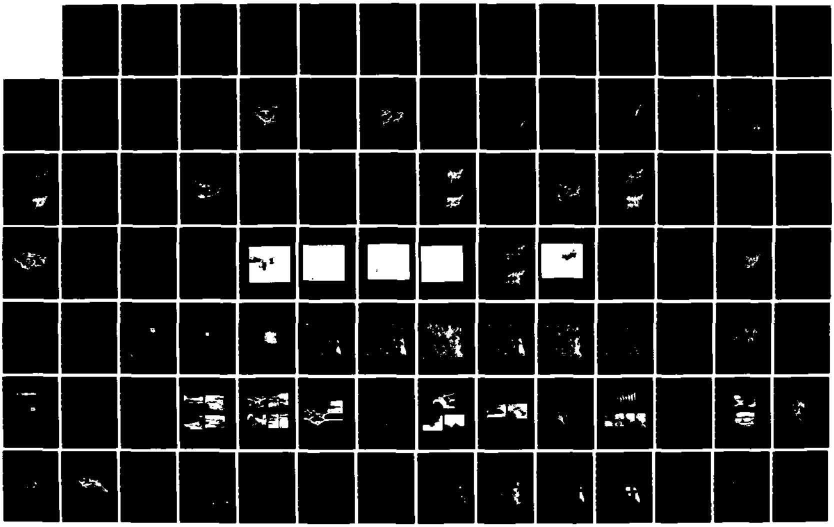
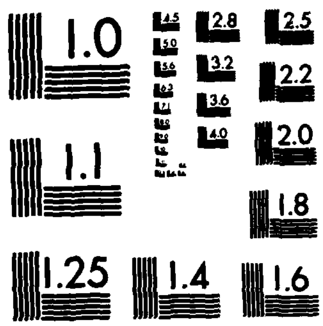




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Local officials are also fearful of the local fiscal impact of smaller units and higher densities. In the Chicago suburb of Hoffman Estates, an "affordable" subdivision of $90,000 homes was recently rejected. According to local officials, homes worth less than $100,000 wouldn't produce enough property taxes to offset their demand on city services (McCarron & Tyner 1982). Although infrastructure costs can be greatly reduced by higher densities, school costs and other service costs that make up the primary generators of the local tax levy cannot. Although local zoning ordinances are the regulatory structures through which these issues are played out, it is in reforms to tax and spending programs where the many impediments to higher residential densities will be resolved. Moves that are currently underway in different areas to remove the dependance of revenue generation on property values include higher taxes on utility bills, new user fees, higher vehicle license fees, and a shift of school costs to state income taxes.

Although zoning ordinances are the primary local land use regulatory tool used to retard innovation in housing size and density, they are often accompanied by subdivision ordinances and developers' fees that are used to promote exclusionary objectives.

In sum, changes in housing size and density provide the potential for major economies in wood use. These changes are beginning to occur at an increasing pace due to changes in

energy, capital, labor and material costs. However, this great potential is faced with a set of barriers of perhaps equal magnitude. A thirty-year accumulation of suburban social expectations and values; a fiscal structure based on a steadily expanding property tax base; fragmented land use decision making within large urban systems; and the inertia of existing ordinances and policies will continue to retard these trends. However, pressure from the rapid formation of new (and smaller) households caused by the maturing post-war baby boom and increased numbers of childless couples and singles will provide a powerful social force for changes in housing size and density.

__Economic and Financial Factors__

Capital scarcity is projected to be one of the primary influences on future changes in the building industry. Fundamental changes occurring in the United States and the international economy will make it unlikely that home buyers will be able, as they have in the past, to borrow large amounts of money for long periods at low interest rates. According to George Sternlieb, Director of the Center for Urban Policy Research at Rutgers University, today's depression in the housing industry signals "the end of an era of home ownership in America that began in the 1930's" (McCarron and Tyner 1982). From now on, according to Sternlieb, "homebuyers will compete for mortgages at the same money market window used by capital-hungry corporations" (Mc-

Carron and Tyner 1982). Because of greatly increased housing acquisition and maintenance costs, housing is not predicted to maintain its strong role as an investment, in the past a major advantage over rental housing. If so, this will produce a strong incentive for a shift toward more townhouses, attached houses and walk-up apartments, with a resultant decrease in wood use.

Capital scarcity will probably also discourage the significant expansion of more capital-intensive factory-built housing and capital-intensive component manufacturing enterprises. The effect of this on wood use is unclear, although larger scale enterprises tend to adopt innovations at a faster rate than small operators. Therefore, this could have some negative influence on the innovation process.

Most observers feel that capital scarcity and higher costs will encourage, not discourage, the diffusion of previously mentioned innovations such as truss systems, reconstituted panel products, and others. Several reasons are given for this judgment. First, the adoption of most of these innovations does not require major capital investments. Observers also feel that many of the needed investments have already been made in such cases as reconstituted panel production plants. Finally, since most of these innovations will contribute to the goal of affordable housing through reduced labor and materials costs, they will become increasingly economically attractive.

Historically, federal poli-

cies have encouraged the single-family detached dwelling. In the 1930's, the birth of the FHA-insured, level-payment, self-amortizing long-term mortgage, supplemented after WW II by VA mortgage guarantees, created millions of single family homes that would otherwise have been economically unfeasible. These inducements have been strongly reinforced by the federal tax code, which allows imputed income from real assets, including housing, to pass untaxed, and also allows the deduction of mortgage interest payments and local property taxes from federally taxable income. In addition, capital gains on houses receive favorable tax treatment. However, as mentioned above, inflation and increased real costs have negated many of these incentives, and will therefore reduce their influence on single-family home production.

The economics of competing materials, primarily steel and plastics, is another area of potential impact on wood use innovation. The recent displacement of wood-based composition sheathing is a case in point. Upon examination, however, strong competition with these other materials does not appear to be on the horizon. Currently 3½ million metric tons of plastics are used in the housing industry (Modern Plastics 1982), much less than the 8 million tons predicted in 1972. Plastics industries will benefit from the growth of some wood-use innovations such as resin-bonded wood. However, many of the plastics innovations likely to impact housing construction

are not directly competitive with wood. Examples of these projected innovations include cosmetic fixtures and amenities, solar heating and cooling systems, increased volume of insulation, skylights, and decorative laminates (Modern Plastics 1982). The use of steel in housing construction is growing in the area of light-gauge steel framing. Sales of light steel for framing more than doubled between 1975 and 1980 (Professional Builder 1981). However, observers of housing materials use trends generally agree that steel framing does not hold the potential for becoming a significant competitor of wood framing materials. However, to the extent that steel framing use increases, the use of wood framing materials will obviously decrease.

REGIONAL GROWTH TRENDS

America is always thought of as a "mobile society." The analysis of the 1980 Census has not only verified that our society is still on the move, but dramatic new trends were identified. The most dramatic trend demonstrated that, for the first time since the settlement of the U.S., migration was a more significant regional growth determinant than birth rate. A dramatically new migration trend was seen as well; for the first time since the 1800's, the population growth rate in nonmetropolitan counties exceeded the growth rate in metropolitan counties. Another area of significant change quantified on the recent Census analysis will result in a new definition of the "average" family. The Census found a significant increase in the number of individuals living independently or sharing housing with unrelated adults. The factors causing these trends and their future scenario has provided the topic for much discussion and debate.

One of the primary factors affecting variations in wood use by region is concrete floors. Termite problems common in the southeast require that homes be built with concrete floors rather than the conventional floor joist system. The concrete floor can result in 25% less wood used in the home. Regional style preferences also affect the quantity and type of wood used in new house construction. Regional variations in wood types and quantities used in housing are delineated in a later section of

this report titled "Wood Products Used in Housing." Please see Tables D-G, pages 10-13.

Nonmetropolitan Growth

The 1970's brought a new trend in migration patterns. For the first time in this century, population growth rate (and economic growth) in nonmetropolitan counties exceeded the growth rate in metropolitan counties. Between 1970 and 1977, nonmetropolitan counties grew by 9.1% compared with metropolitan counties which grew by 5.4%. These growth rates translate to 4.9 million persons in nonmetropolitan counties and 8.1 million persons in metropolitan counties (Brown 1980). Furthermore, Jackson (1981) makes the point that recent metropolitan growth is almost entirely due to annexation and reclassification of nonmetropolitan counties.

Prior to this shift, nonmetropolitan areas continually lost population to urbanizing areas. Although it is difficult to separate this urban sprawl from nonmetropolitan growth which does not depend upon an urban core, most true suburbs are located in counties already classified as metropolitan. To further demonstrate that the increase in nonmetropolitan growth is not urban sprawl, Lichter (1980) has found that the rate of growth outside incorporated places within nonmetropolitan areas was twice that of the national average during the post-1970 period. Brown (1980) has taken an even closer look at nonmetropolitan growth and has found an inverse relationship between the magnitude of the migration turn-around

and the level of urbanization of nonmetropolitan counties. The growth rate in nonmetropolitan counties which included a population center of 25,000 was 0.4% per year in the 1970's while totally rural nonmetropolitan counties grew at a rate of 1.1% per year.

Brown also demonstrated that the magnitude of in-migration was greater in nonmetropolitan counties that were physically separated from Standard Metropolitan Statistical Areas (SMSA's) compared with contiguous nonmetropolitan areas (0.8% and 0.5% per year, respectively). Only 2 economic subregions, the Mississippi Delta and the Central Corn Belt, continue to experience net out-migration.

The reasons for the increased growth rates of nonmetropolitan counties are difficult to ascertain. Brown (1980) suggests three interrelated factors:

1. Economic Decentralization. Although mining and energy extraction account for some of the decentralization, service-performing jobs now account for the majority of nonfarm jobs, which increased by 22% between 1970 and 1977.
2. Preference for Rural Living. As employment constraints to living in rural areas are reduced and people become more frustrated with the crime and blight of the cities the rural lifestyle becomes more attractive.
3. Modernization of Rural Life. Rural areas can no longer be considered isolated and backward. Improved local roads, the interstate highway

system, centralized water and sewer, telephone service and cable television have all helped to provide rural areas with the amenities of the city.

Suburbanization

Suburbanization, the growth of residential population on the periphery of certain large cities, began in the 1920's in some major U.S. cities. This regional growth occurs both through the outward movement of population from the central city as well as the in-migration to the urban periphery from other areas. Some of the many reasons for suburbanization are: (1) Rising land values in the central city; (2) Increased communication and transportation; and (3) Deterioration of the city due to crime, noise, congestion and air pollution.

The sprawl of residential development on land, often prime agricultural land, has been judged by many to be detrimental to the natural environment as well as the economic viability of the municipality that must provide services such as: fire and police protection, adequate schools, and waste disposal.

Land use regulations have been implemented in many areas with varying degrees of success in controlling urban sprawl. The recent slump in the general economy and the housing industry brought a reduction in the growth rate of suburbs.

Sunbelt Migration

One of the most familiar regional migration trends is the

well-documented move the sunbelt. Traditionally, dating back to the late 1800's, the south exported population. Poverty, economic underdevelopment, labor surplus, prejudice and discrimination are all given as reasons for the move from the south. A reversal in this trend began after World War II. Economic opportunities in the form of low taxes, investment incentives, cheap labor and land began to draw industries and individuals soon joined the move (Brown 1980). The migration to the sunbelt continued through the 1970's, but was less dominant than previously (Leven 1981). Nonetheless, the south gained over 5 million persons between 1970 and 1975; this growth exceeded that of all other regions combined. Brown (1980) documents that most of these people migrated from the North Central and Northeast regions. The motives for this migration trend include economics, lower fuel and housing cost and extensive job opportunities as well as a warm climate.

Geographic areas in the south accounting for substantial growth included: Texas, the mid-south uplands (Tennessee, Kentucky, northern Alabama and Georgia) and the Ozark-Ouachita plateau (Arkansas and Oklahoma) (Roseman 1977 cited in Brown 1980). Although California has been the destination of many immigrants to the sunbelt, its popularity decreased dramatically in the 1970's. Between 1965 and 1970, 70% of all immigrants to the west moved to California; in contrast, between 1970 and 1975 only 33% of all immigrants to the west moved to California. Table P, "U.S.

Population Growth by Region" will illustrate the points mentioned here.

Table P. U.S. Population Growth by Region
(annual % rate of change)

	1940-50	1950-60	1960-70	1970-75
U.S.*	1.37	1.71	1.28	0.92
Northeast	0.93	1.24	0.93	0.16
New England (a)	0.99	1.20	1.19	0.60
Middle Atlantic (b)	0.91	1.25	0.85	0.02
North Central	1.03	1.47	0.92	0.35
East North Central (c)	1.34	1.72	10.5	0.32
West North Central (d)	0.40	0.91	0.58	0.43
South	1.31	1.61	1.42	1.60
South Atlantic (e)	1.86	2.20	1.83	1.84
East South Central (f)	0.63	0.49	0.61	1.12
West South Central (g)	1.07	1.54	1.31	1.51
West	3.43	3.29	2.16	1.62
Mountain (h)	2.02	3.00	1.89	3.04
Pacific (i)	3.98	3.39	2.24	1.14

*Continental U.S., excluding Hawaii and Alaska

(a) Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

(b) New Jersey, New York, Pennsylvania

(c) Illinois, Indiana, Michigan, Ohio, Wisconsin

(d) Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota

(e) Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia

(f) Alabama, Kentucky, Mississippi, Tennessee

(g) Arkansas, Louisiana, Oklahoma, Texas

(h) Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Wyoming

(i) California, Oregon, Washington

Source: Leven, Charles. 1981. Regional Variations in Metropolitan Growth and Development. Institute for Urban and Regional Studies. Washington University. St. Louis, Missouri.

Urban Infill

A projected migration trend which is receiving significant attention in the literature is labled "urban infill." The Real Estate Research Corporation (RERC) (1980) defines urban infill as residential development on vacant parcels of land surrounded by urban development.

Several references (Hoyt 1978; Houstoun 1981) document the availability of this vacant land. In a recent study of 86 cities by the RERC, approximately 25 percent of the land was determined to be vacant. It was estimated that approximately half of that land was available for development.

Although this trend is currently being discussed by planners, population statistics as yet have not verified that individuals have chosen urban infill housing. Reasons for this projected trend vary, some include:

1. Changing lifestyles, resulting in increased numbers of people choosing to live independently or with unrelated adults close to employment.

2. Urban infill housing can be more economical than traditional housing for many reasons: (a) The necessary infrastructure (sewer, water, gas, etc.) is already available; (b) Land acquisition costs can be less than a conventional size lot; (c) Infill housing will most likely take the shape of attached townhouses or apartment buildings; due to economies of scale and common

walls the per square foot costs can be lower than traditional housing.

3. With increasing energy costs, people will be attracted to infill housing by reduced commuting costs and cheaper home heating bills provided by common walls.

4. A final incentive for infill development may be zoning regulations designed to protect valuable agricultural land and natural landscape surrounding the city.

EXPECTED TRENDS IN GROWTH RATES

U. S. Spatial Design Scenarios and Wood Conservation

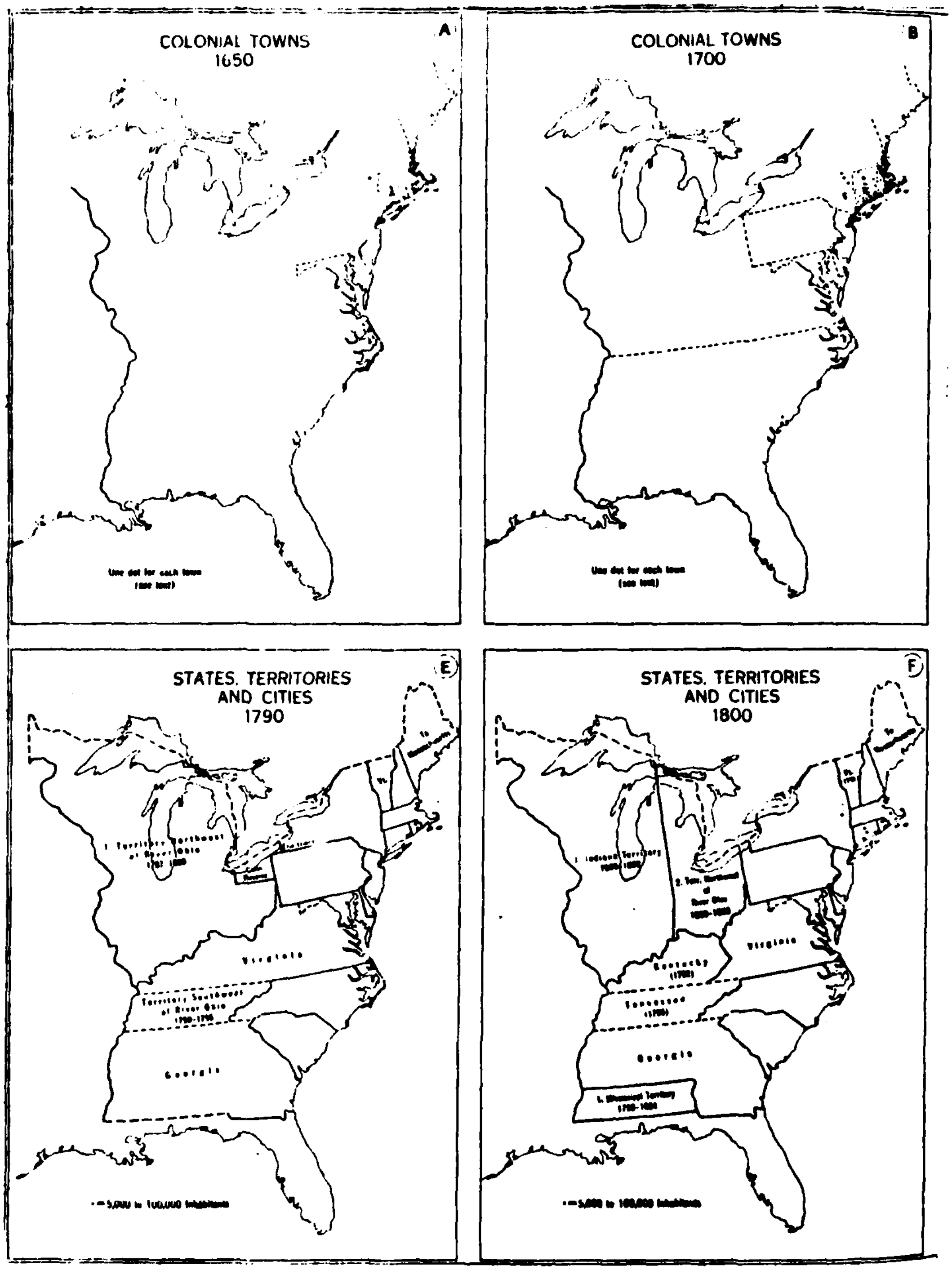
In the pre-industrial age American Indians and their sparse settlements made little impact upon the landscape. The portable wigwam was easily transferred from one site to another. Hogan, long-house and mesa dwelling disturbed the land but little, and used few resources. The resources for fishing and hunting abounded as did an everlasting supply of firewood for heating, cooking and preserving food. The Indians, because of their meager number, life style and religious beliefs were in harmony with their life support system.

APPENDIX

EXPECTED TRENDS IN GROWTH RATES

When the European settlers arrived in droves with their appetite for safety, survival and comfort, they demanded more from the sustaining landscape. Forts and log corduroy roads, covered bridges, barns and rail fences all demanded the tree from the forest. Clearing of land for cropping was essential. Concepts of architectural grandeur were expressed as soon as the means to do so were acquired by builders.

The Ohio River and Great Lakes permitted the early settler to penetrate into the country's interior. Following the early buffalo trails and natural waterways, the settlers and their villages were to weave an organic design pattern on the face of the American landscape prior to the industrial era.



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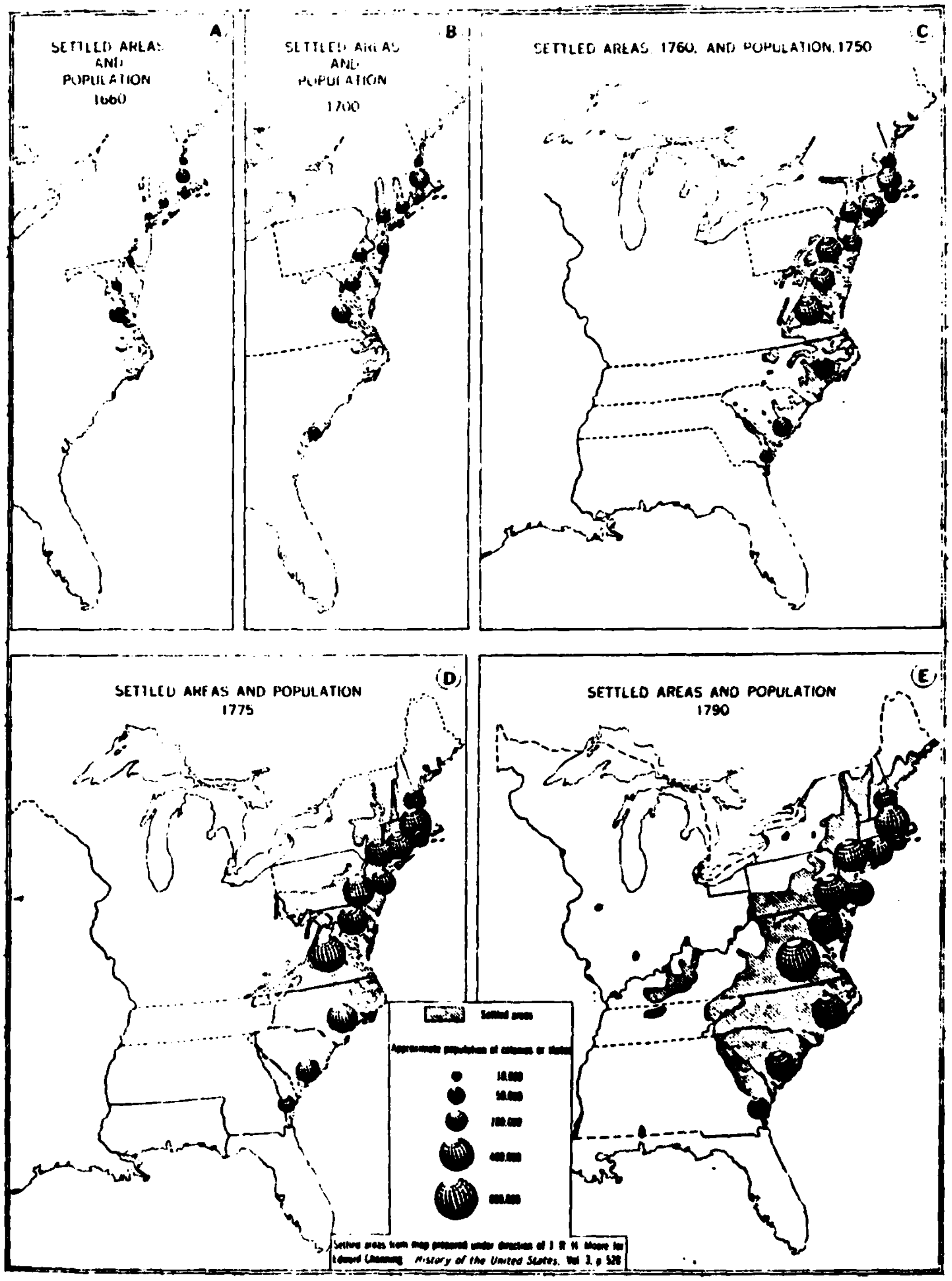
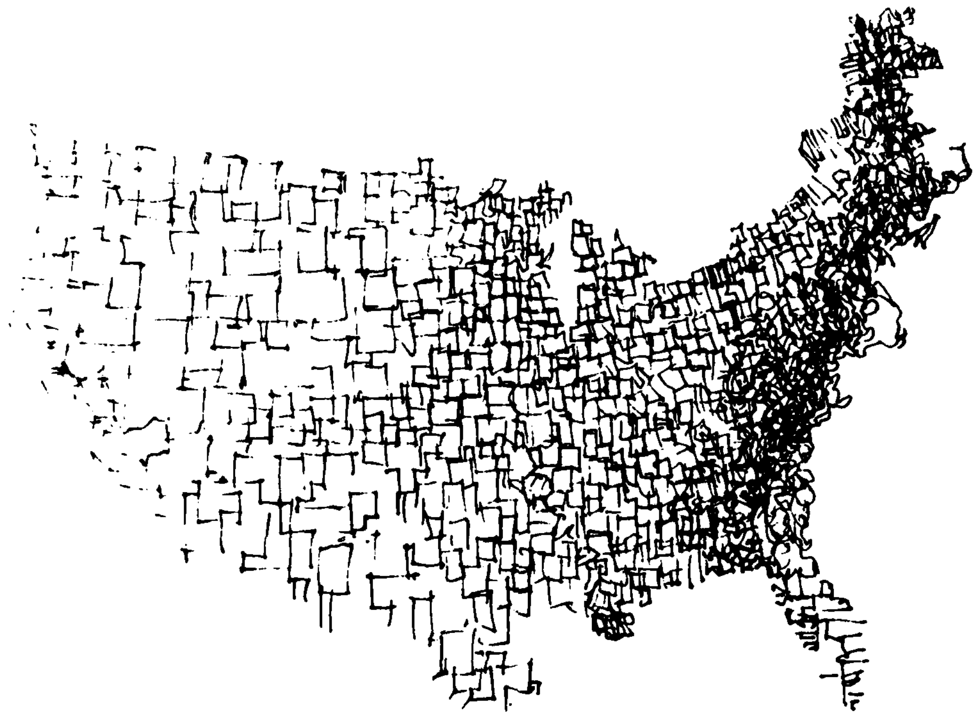


In 1784 and 1785 the Continental Congress mandated the ordinance surveys, a spatial design concept by Thomas Jefferson for rapidly developing the American landscape. The design concept was national in scope and its purposes and implications have, over the years, had far reaching consequences on the uses of natural resources, including wood.

Jefferson's concept resulted in the rectangular grid we see sprawled across the middle of our nation. The purpose of the grid proposal was to organize land on a vast scale for taking possession of wilderness lands. His approach was typical of his age (the Industrial age): standardize, synchronize, and maximize land distribution.

The result was a "massified" landscape (mass produced for mass consumption) and it accomplished its primary objective which was to settle the wilderness and thereby ensure the sovereignty and the security of the Northwest Territories (and later the Louisiana Purchase). It was an industrialized landscape for an industrialized society.



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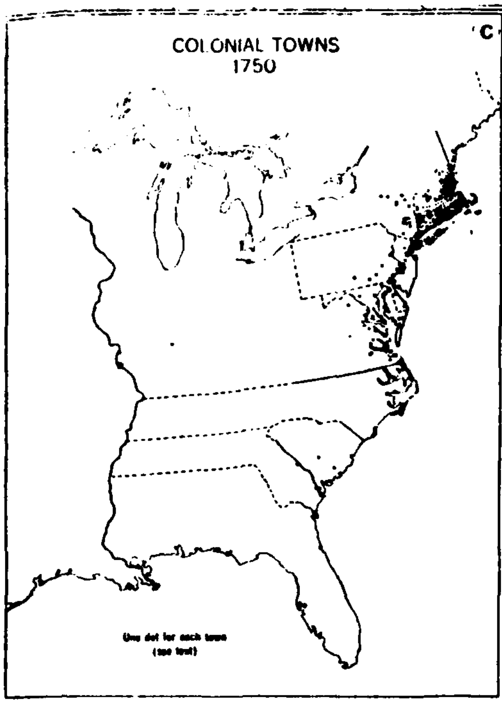

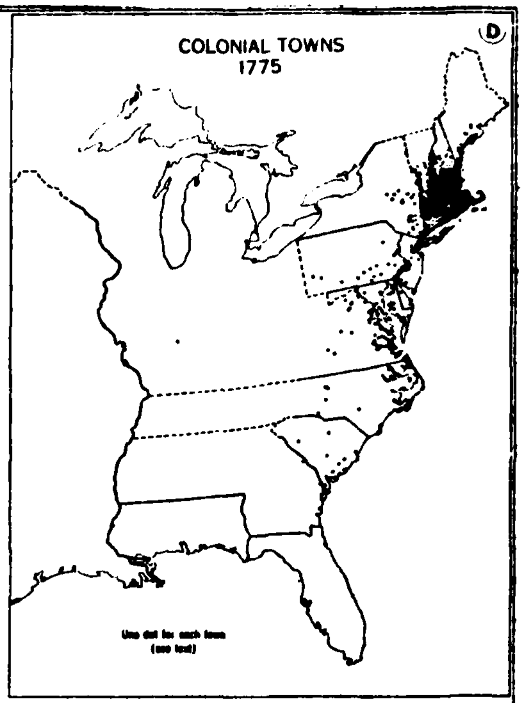

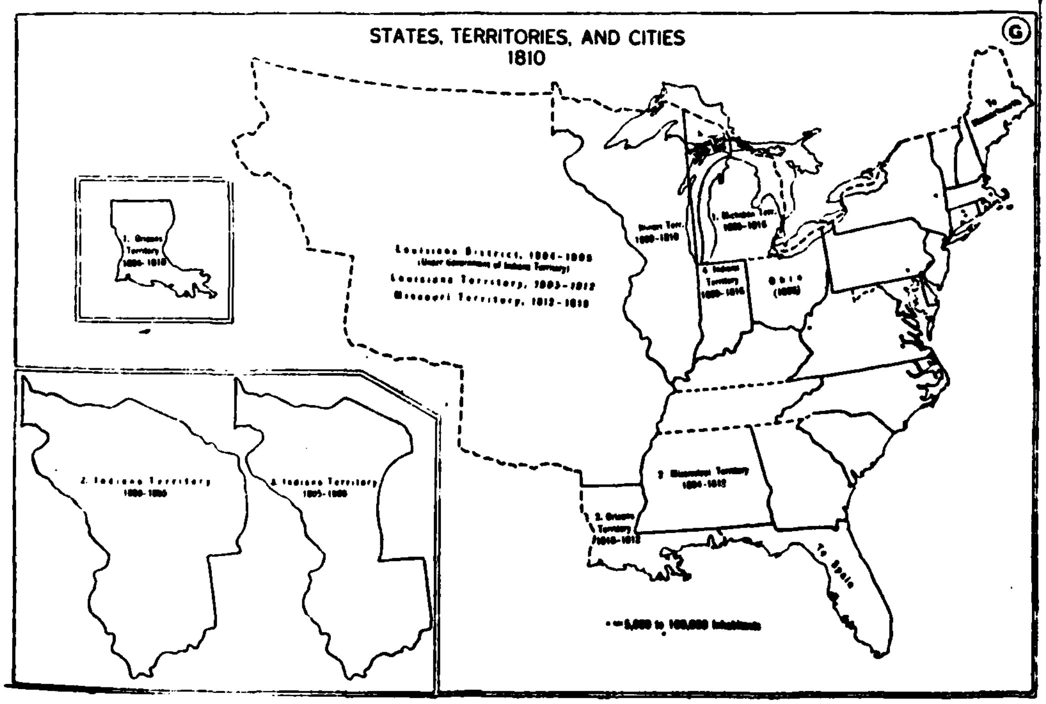

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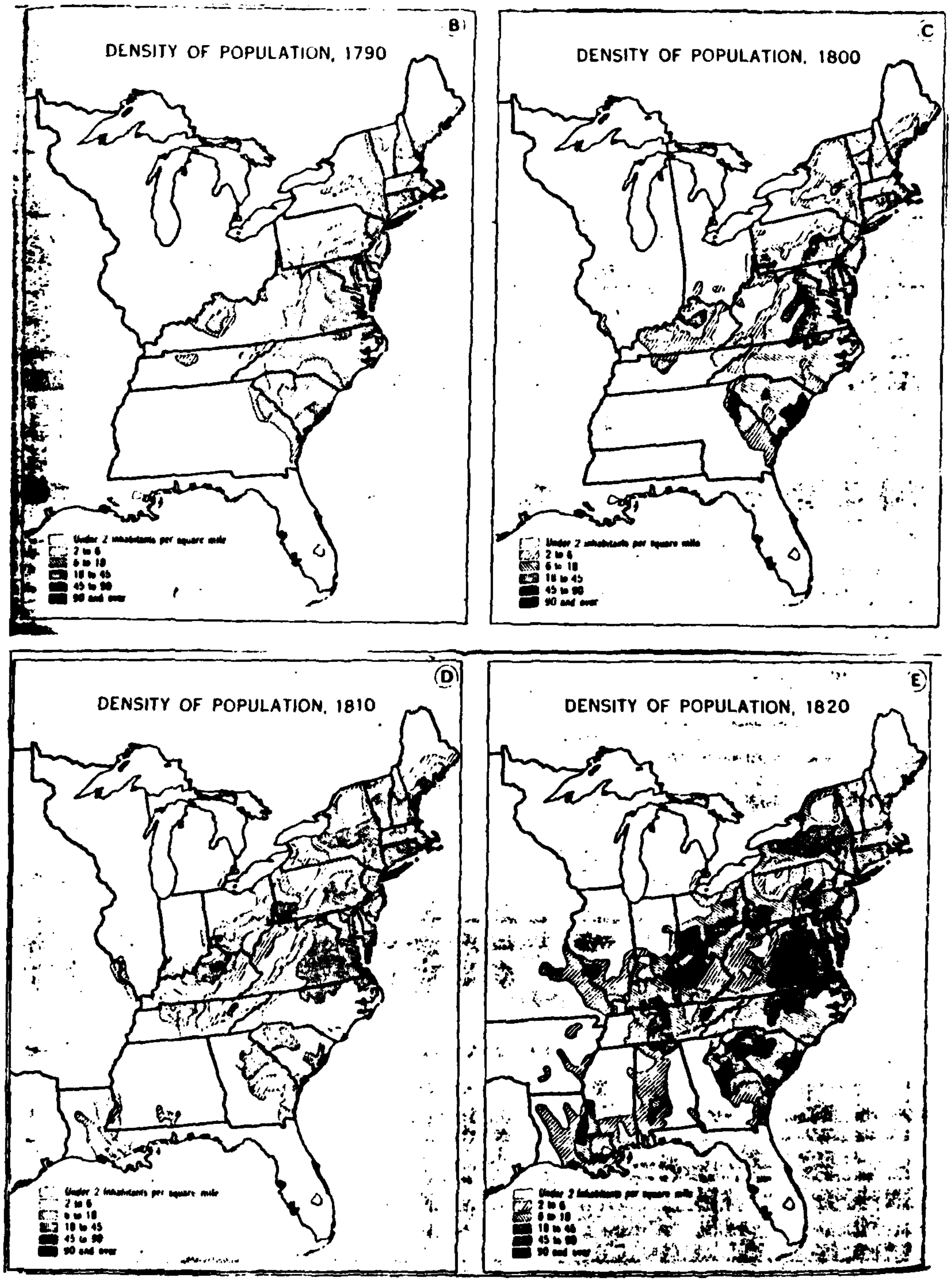

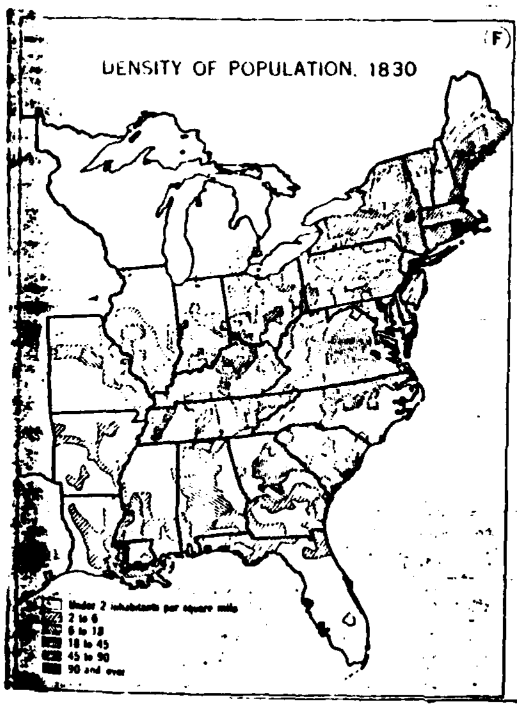

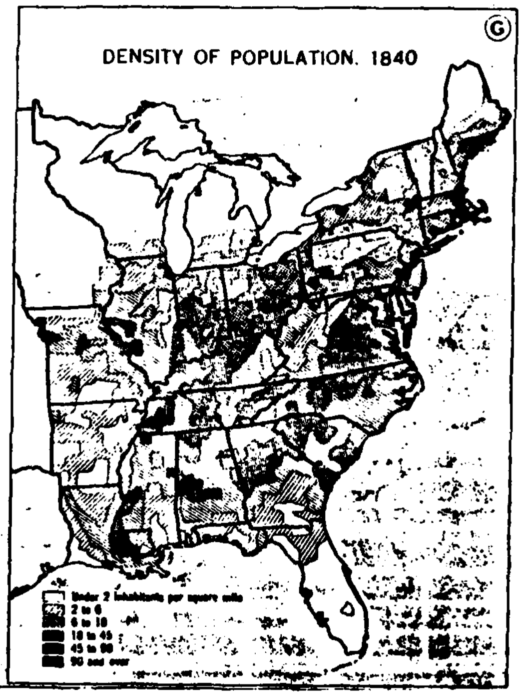

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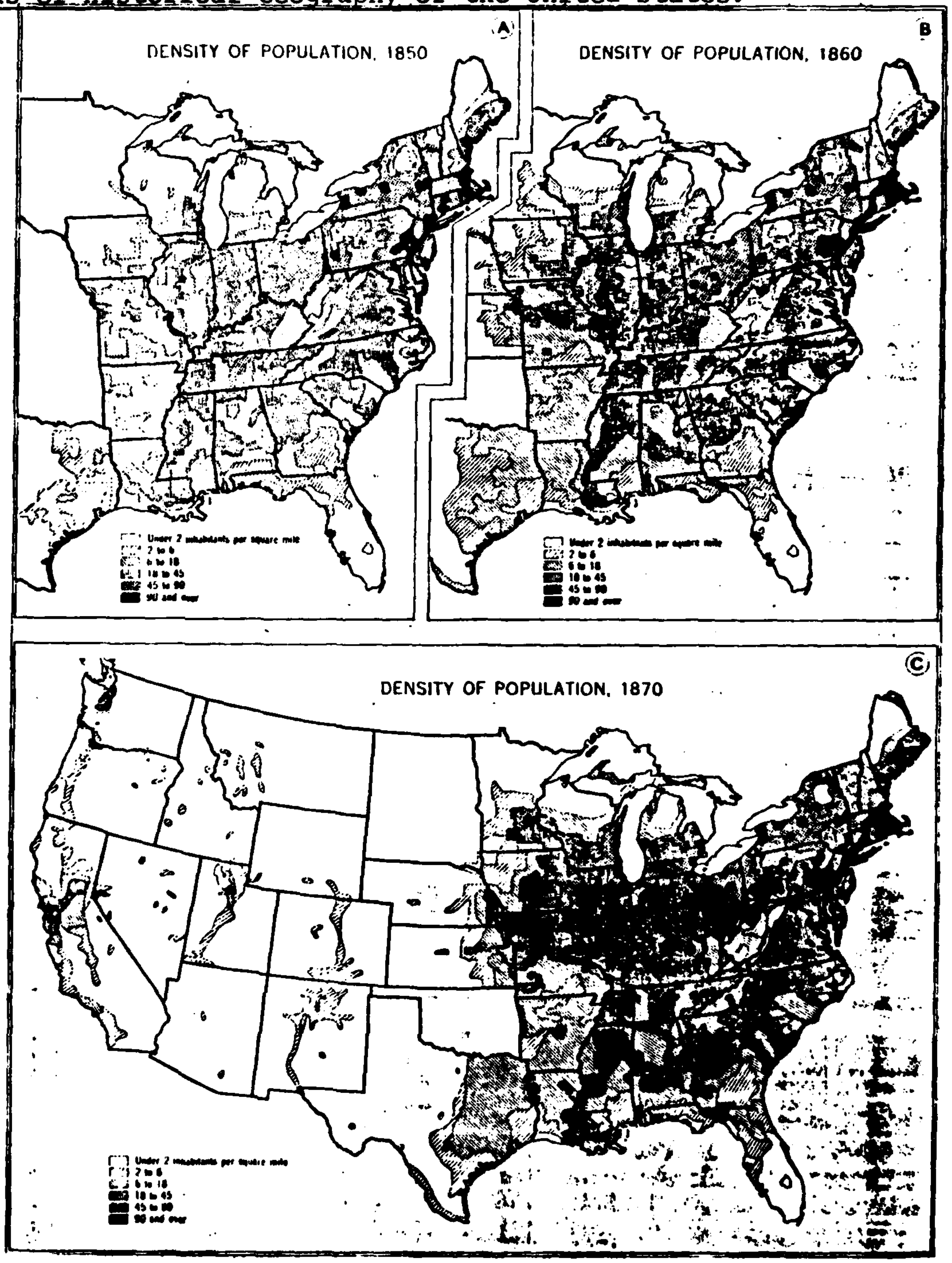

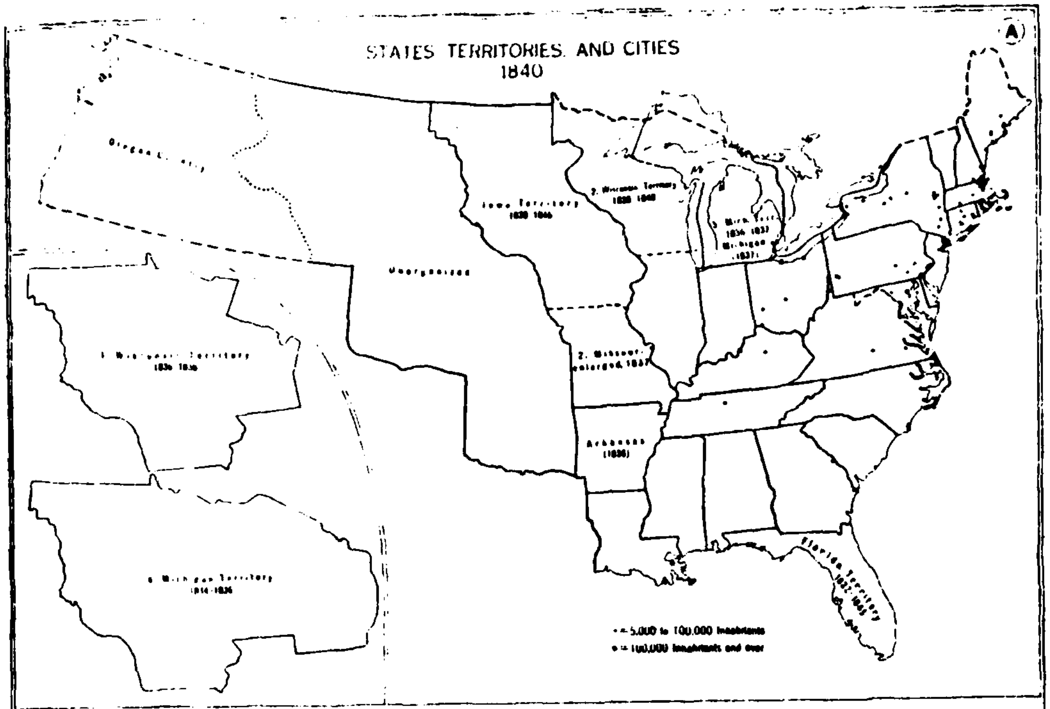

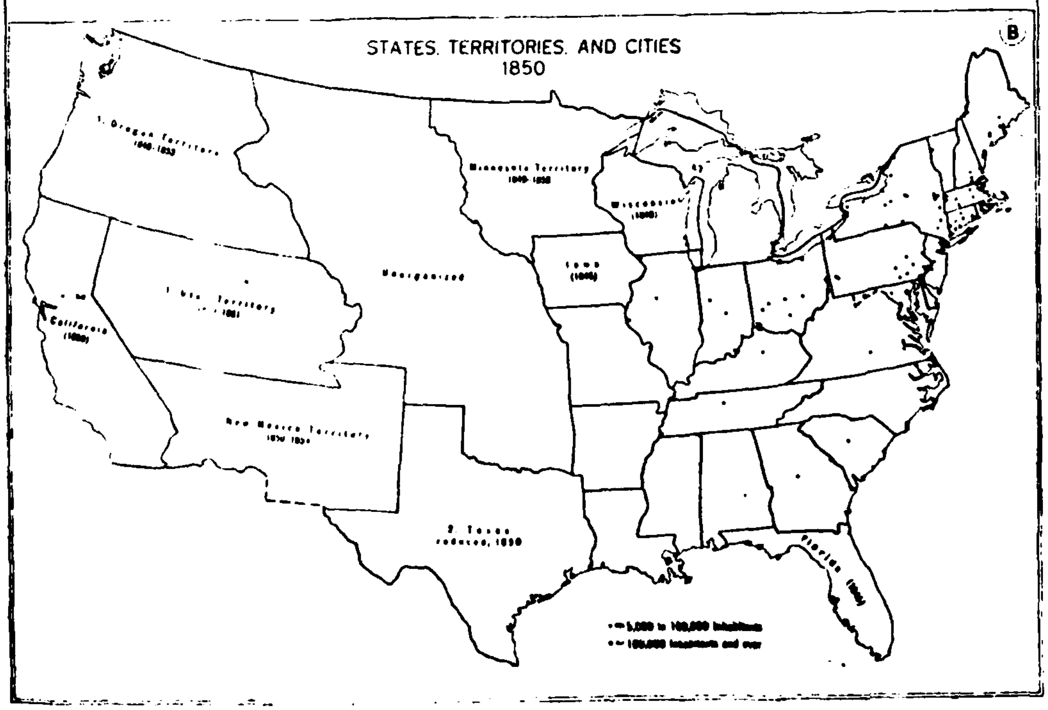

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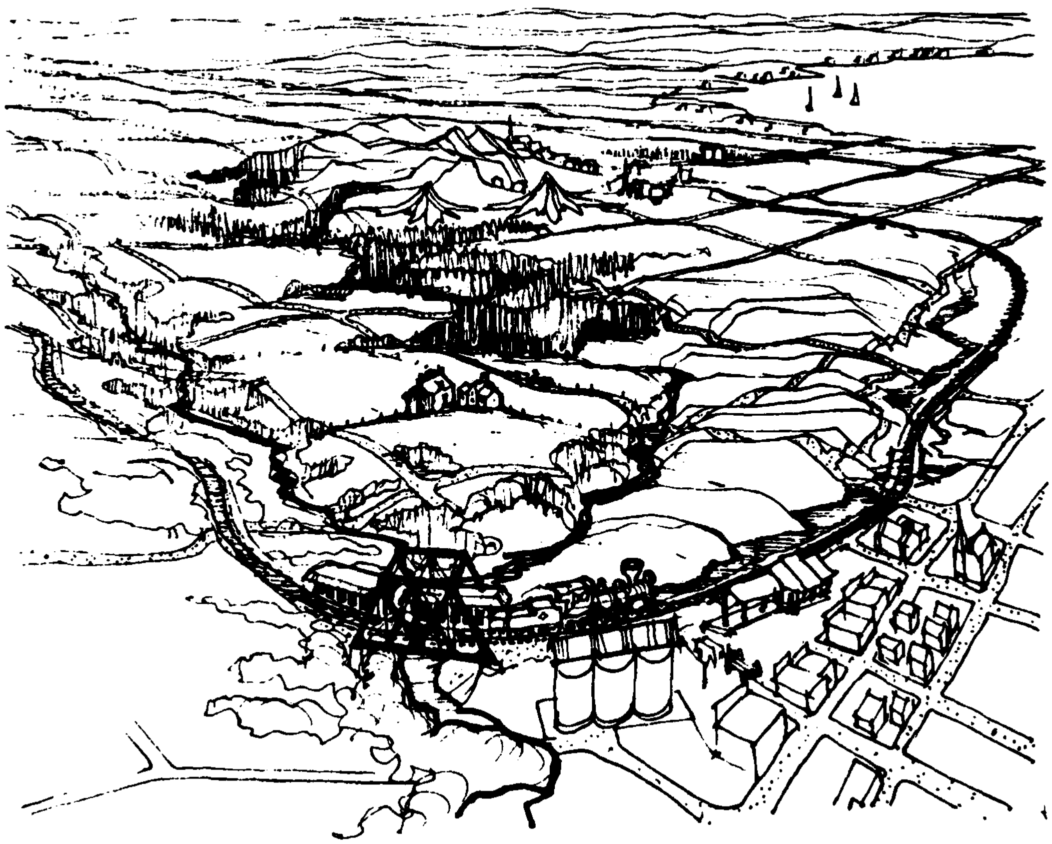
While the grid did permit clear land description, sale and record keeping and ensured the sovereignty and security of the land, its rigid geometric pattern imposed an unnatural system upon one of the most beautiful landscapes on the globe.

Natural trails and wandering Indian pathways gave way to the surveyed straight highways of the future. Railways on flat prairies were as straight as highways until it became necessary to join early towns founded on twisting waterways. Villages gave way to towns and cities. Farms appeared throughout the land and clearing of timber for crops became common practice. The American landscape was beginning to feel the impact of ax and plow as its natural fabric gave way to industrialized potentials.



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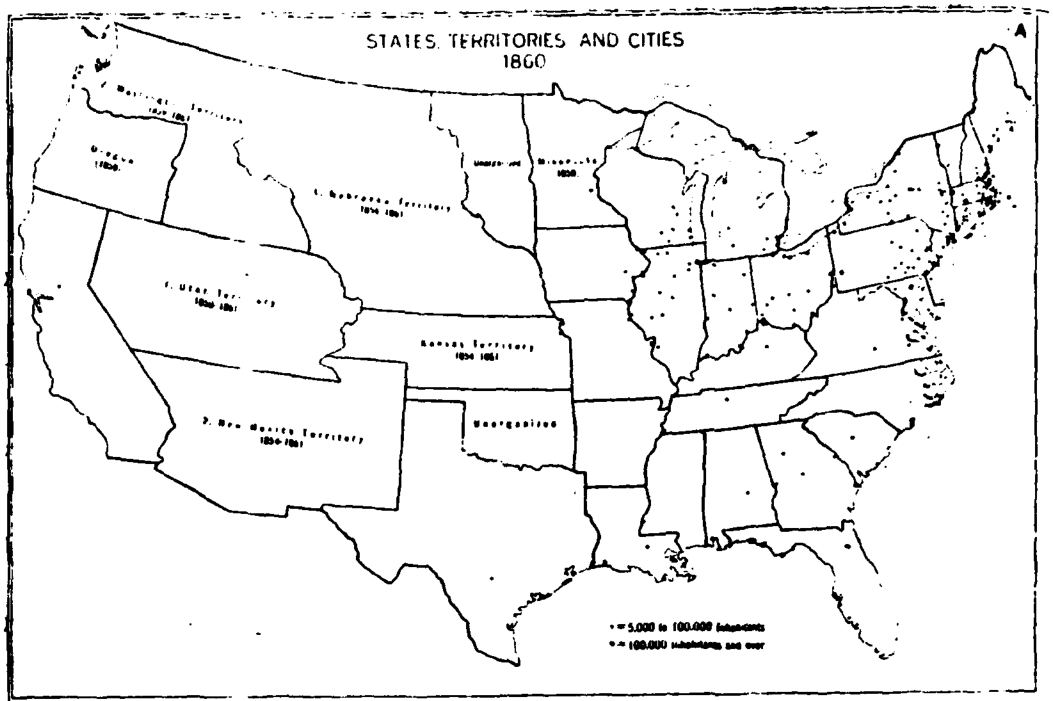

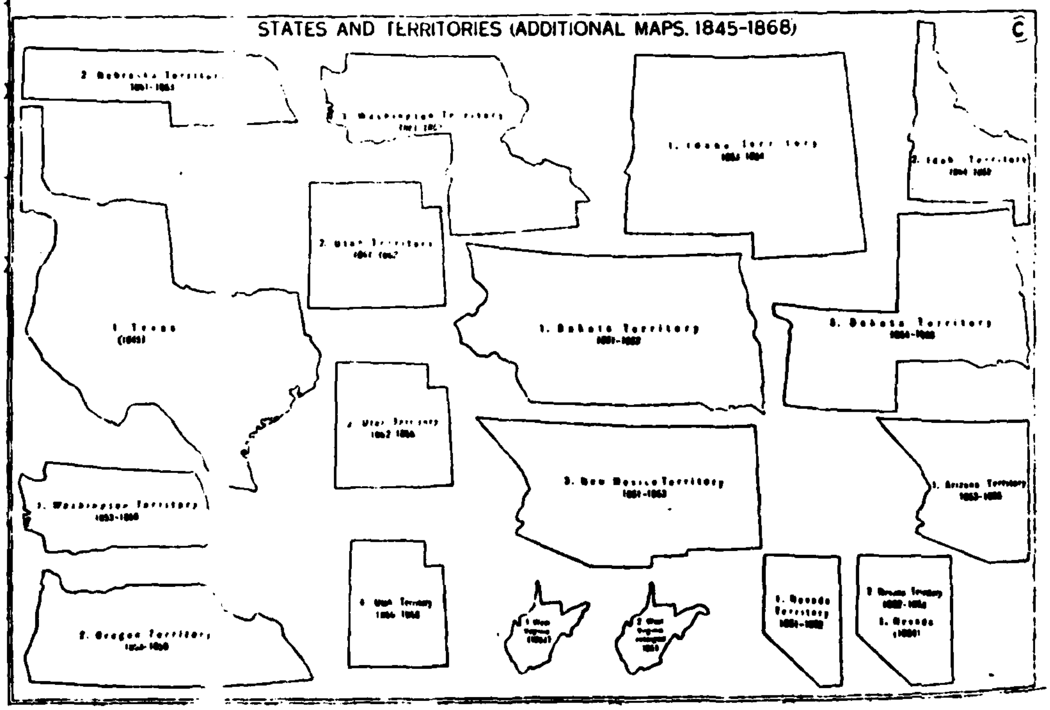

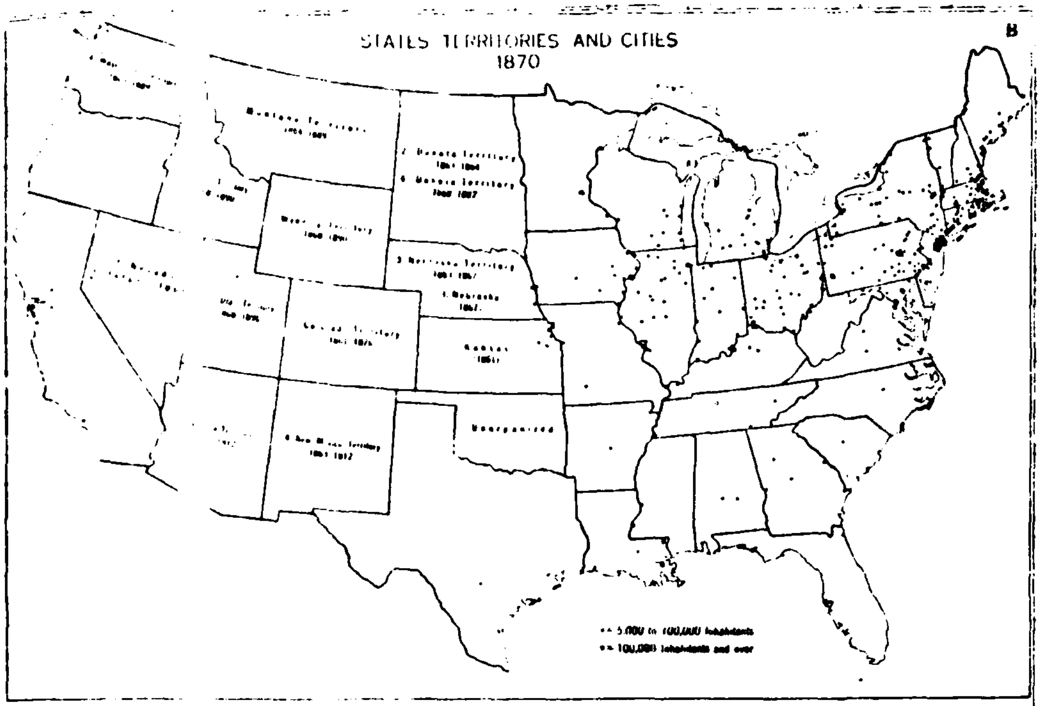

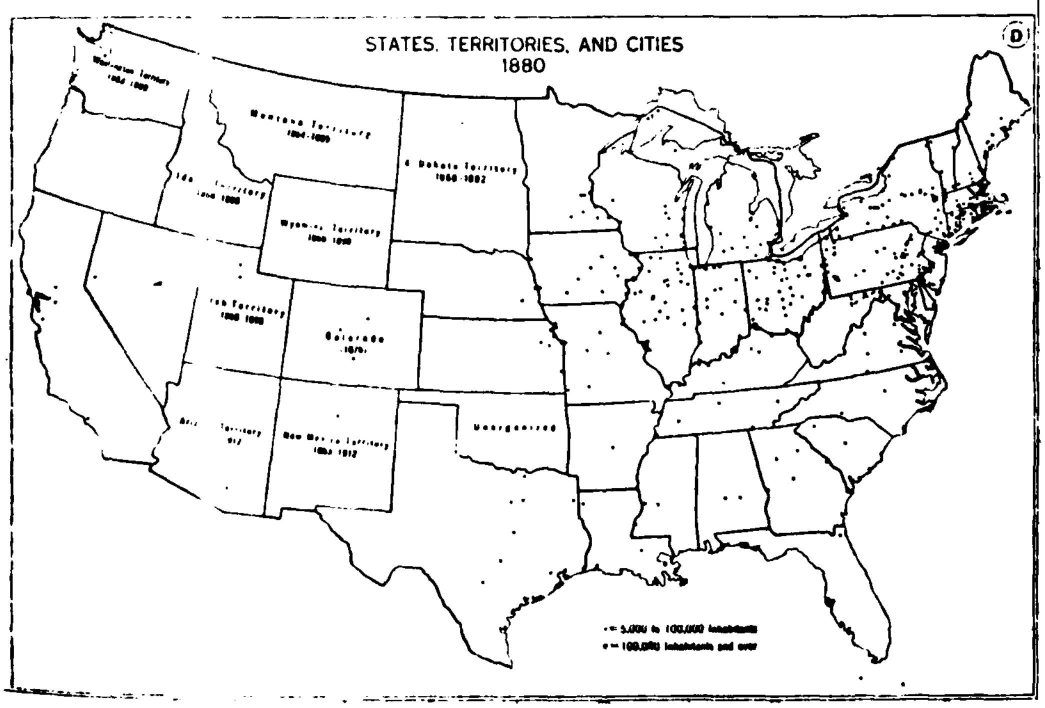

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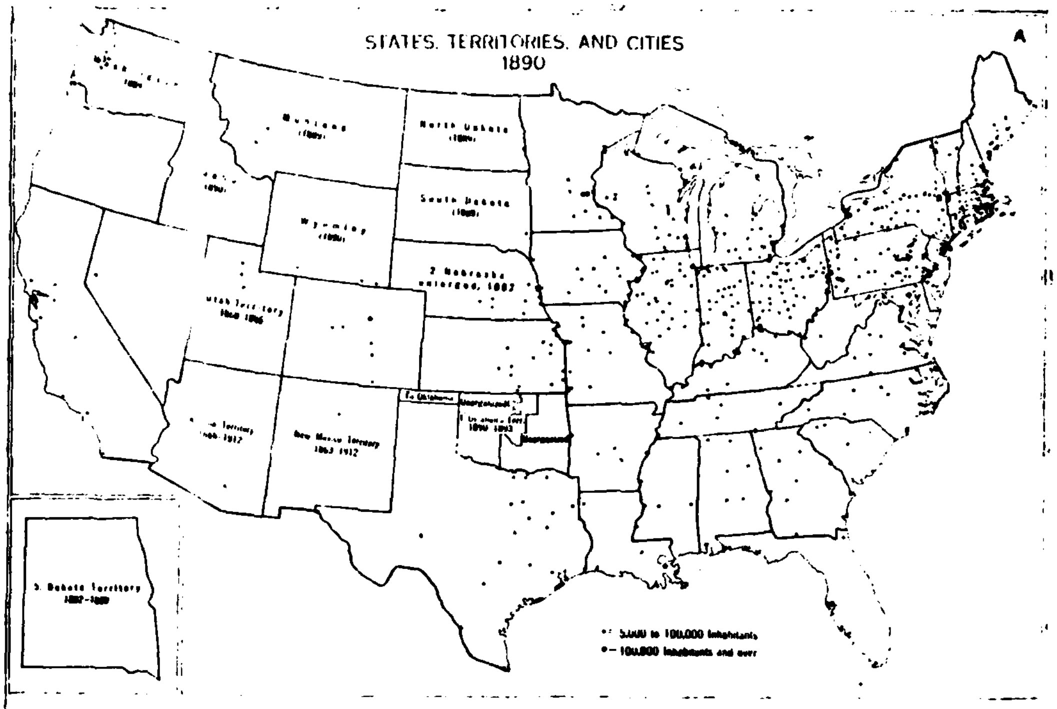

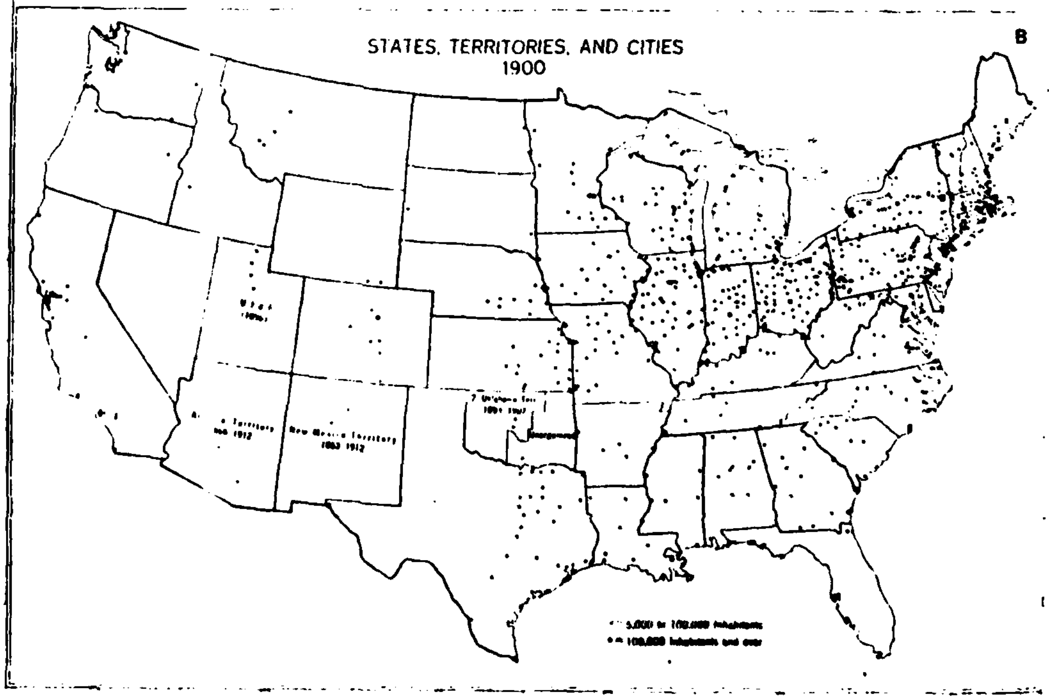

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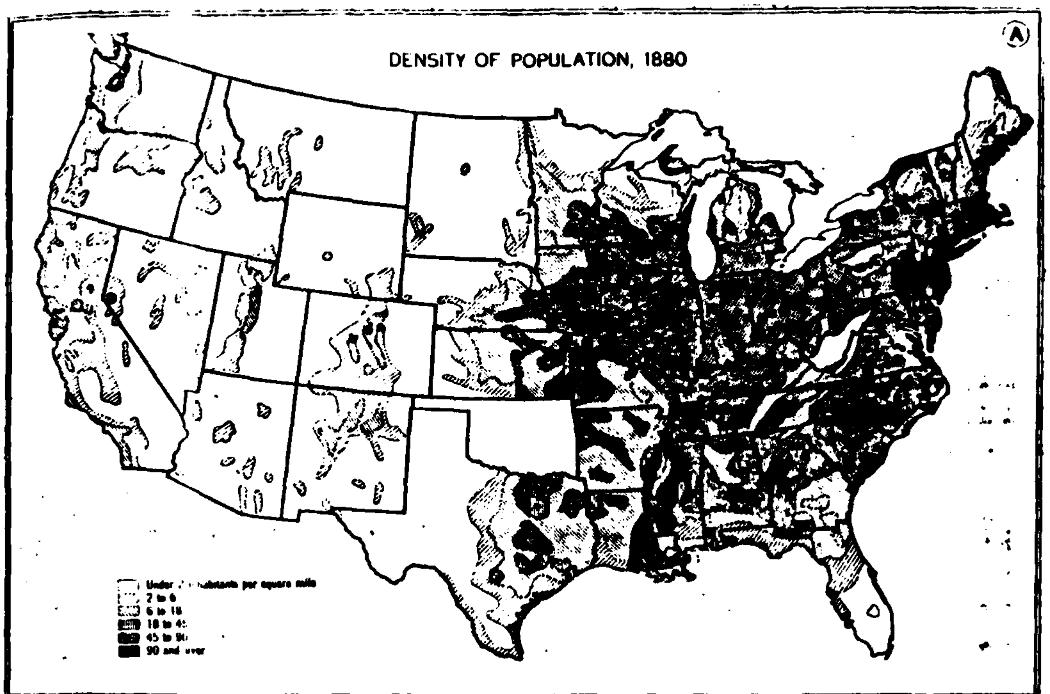
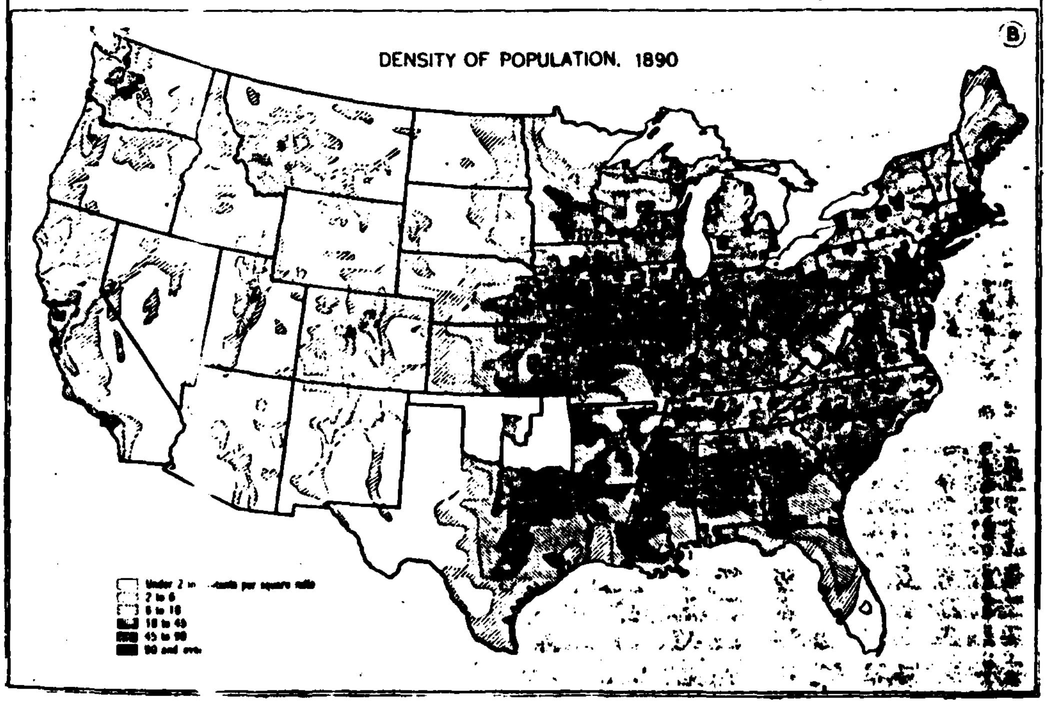
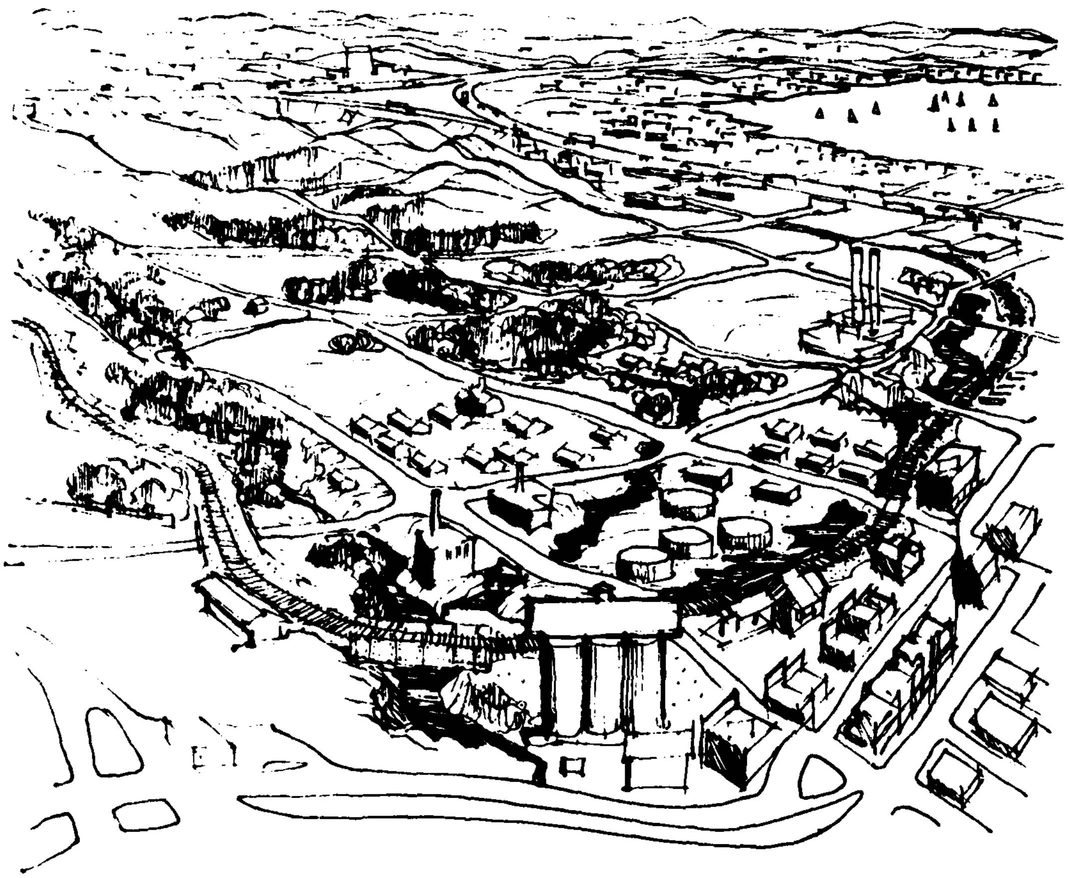




Today we are entering the post-industrialized age which, according to Alvin Toffler and other futurists, is already upon us. While it can be agreed that we are entering a new era, the term "post-industrialized" is a poorly chosen concept. While the term hints at the end of industrialization, it is hard to believe that we will not continue to produce exciting new manufactured goods and services. Perhaps we should call the new era the "eco-electronic" or "eco-cybernetic" era because of solar and communication devices being developed to rehabilitate the damaged national landscape and at the same time are utilized to offer housing and urban development at far less cost to the ecosystem. The "environmental seventies" provided both the moral and economic support to chart an age when professional talent is in place to determine landscape carrying capacities, to design totally new dwellings and communities consuming far less energy and providing liveability. With such talent available, it is time to design a new urban concept.



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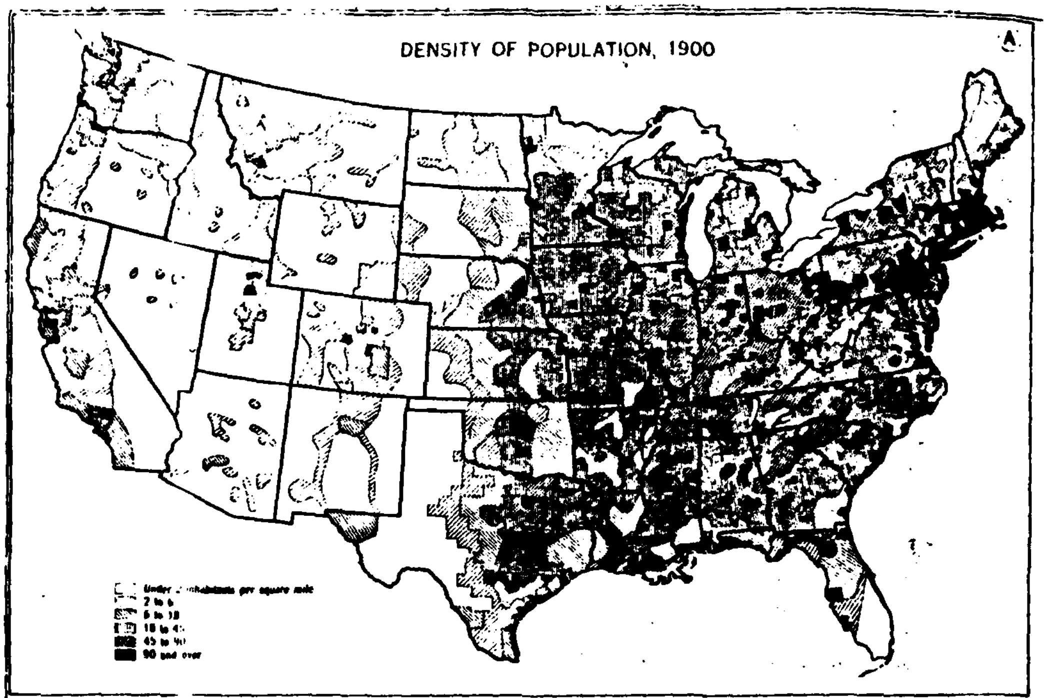

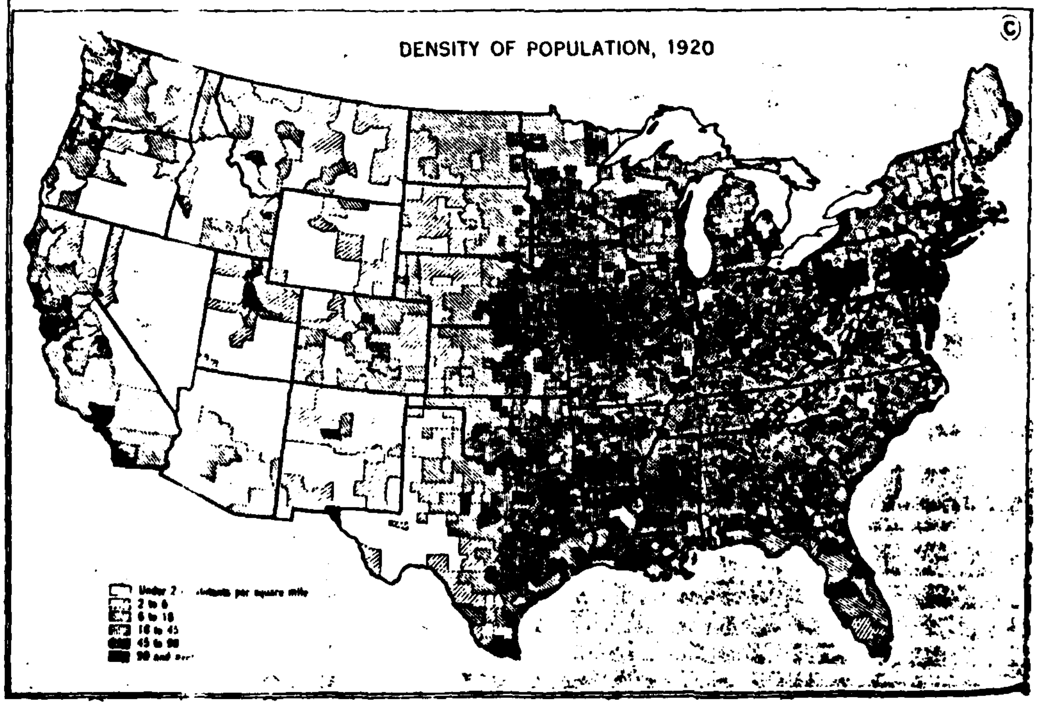

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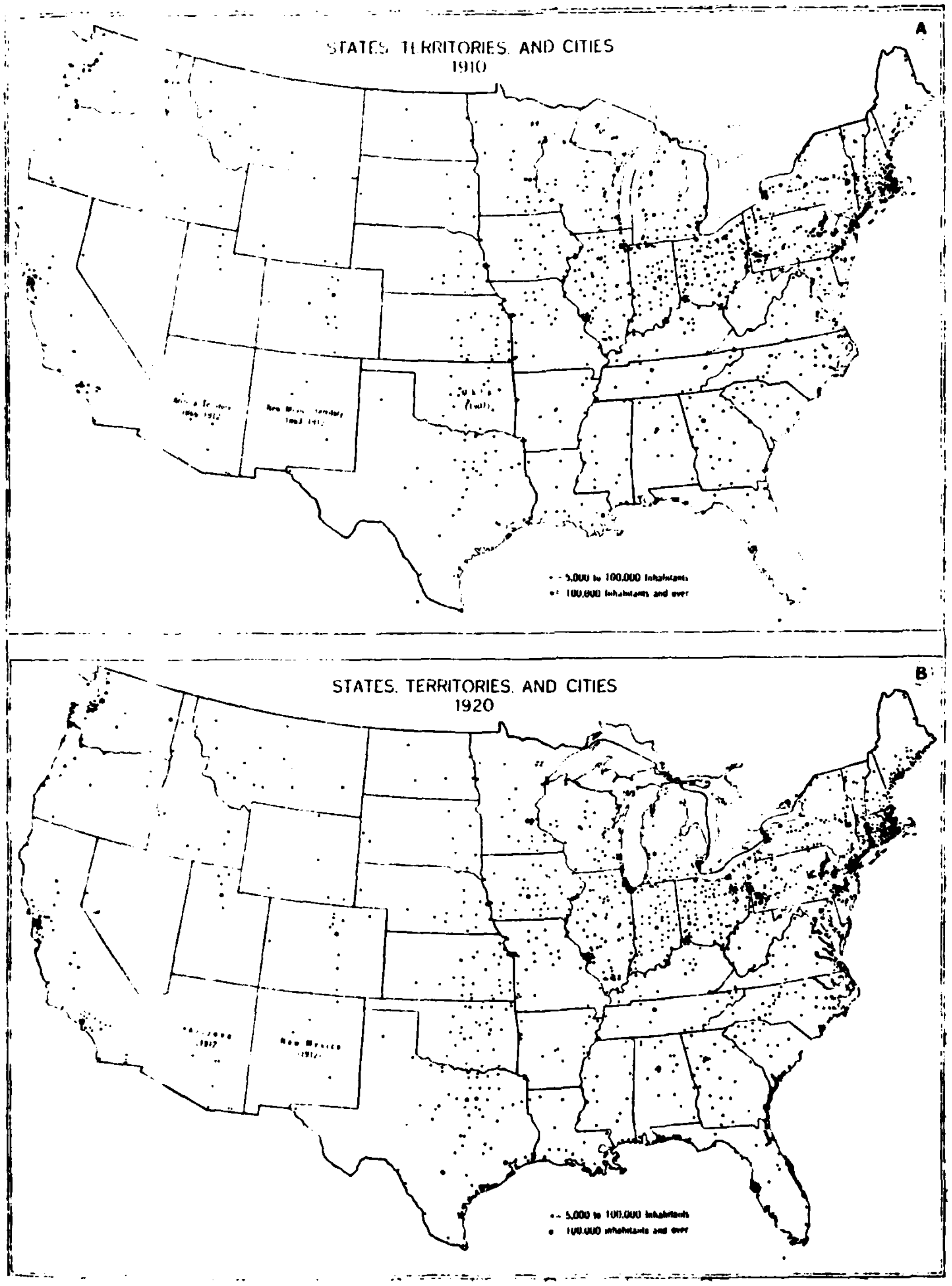


Broadly, the futurists say that this new age will bring a demassification of society, dispersing populations rather than integrating them, and focusing on <u>regionalism</u> rather than nationalism.

If this is true, we therefore need a new spatial design concept for re-structuring industrial space (eco-electronic-cybernetics). Jefferson's grid solved the major land change problem of his time: settling the land. The new spatial design concept must solve the major land change problem of our time: managing the land that we have settled over the last two hundred years.

The way we have developed the land throughout the industrialized age has led to the consumption of wood. A projection of past and present wood uses as well as changing trends will give us a fairly accurate projection of consumption in the future.

However, this is but one development scenario we must explore if we are to accurately predict the use of wood in the future. There is the likelihood that a totally new spatial design for the nation is evolving rapidly and will be accepted by the end of the century.

<u>New Scenario</u>

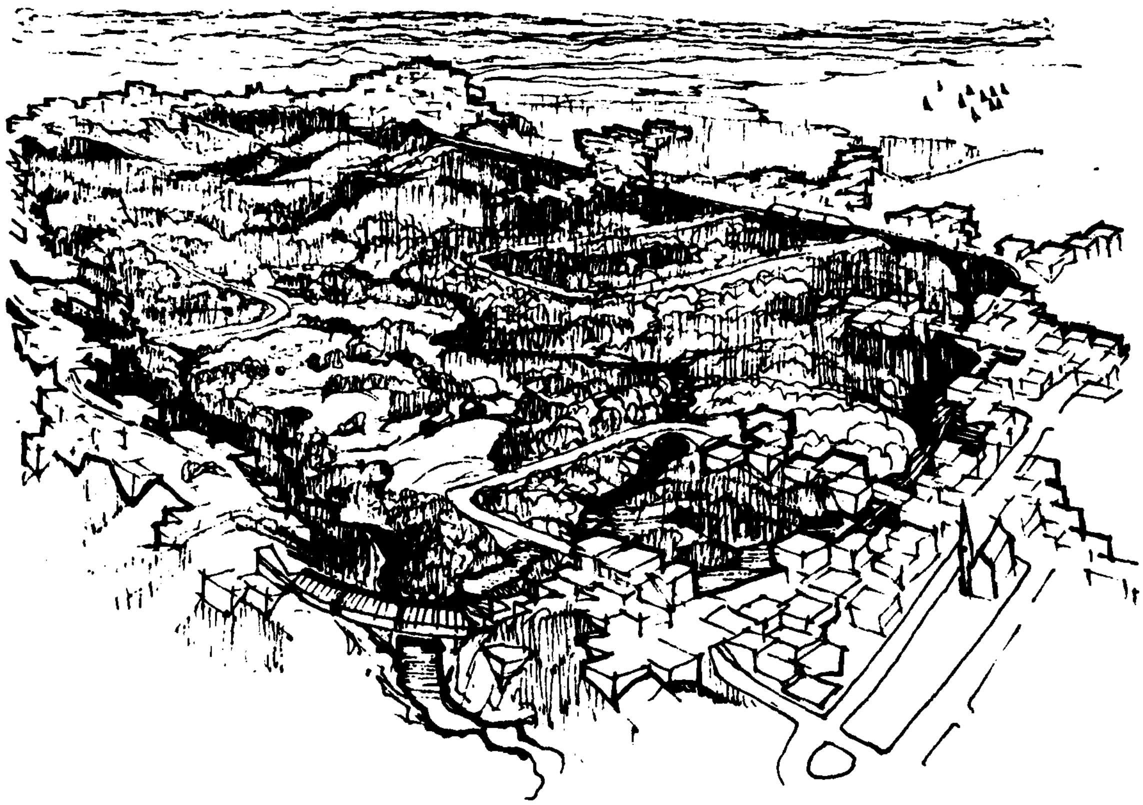
The "environmental seventies" gave us the opportunity to review our national resource consumption patterns and the cost of the present and continuing massive impact they have upon our very life support system.

Through numerous studies, many have concluded that a new spatial design concept must be

developed and adopted that will guide human development in harmony with what remains of these basic land resources. Productive soil, timber and mineral patterns, the flow of clean waters and continuity of natural diversity patterns, the very resources that nourish the nation--must now serve as a "form determinant" for future development. These key sustaining resources should have been respected and no doubt would have prevailed as a form determinant in the beginning, had our nation had the resource professionals and techniques that are in place today.

In these observations the threat to our life support system has been not so much the threat of small urban patterns nibbling away at the resource base of the past (serious as this has been), but the vast scale of our contemporary cities replacing whole square miles of this essential system. Small urban grids do not offer the most compatible of urban patterns in harmony with the organic patterns of the landscape, but these do not compare to the megalopolis grid scale of today.

The grid design concept proposed by Jefferson did open the country without too much short-term destruction. The resultant grid of today offers a totally different aftermath. Our second scenario goes further by suggesting that our nation will be wise enough to alter and accept a development scenario that reflects the resource patterns that can continue to support liveable places and survival. We call this scenario the urban constellation concept.



The Urban Constellation Concept

The earth is a very small place. It shares our sun with eight other planets, 31 moons, hundreds of asteroids and swarms of meteors. Our solar system lies halfway out from the center of our 100-billion star galaxy--the Milky Way. This great wheel, 80,000 light years in diameter, and 10,000 light years thick, is one of over a billion galaxies which may be visible from earth in both galactic hemispheres.

For thousands of years, we have guided our movements on our tiny spaceship with the help of the constellations--imaginary images from Greek and Roman mythology based on apparent star patterns. When Galileo first put the telescope to practical use in 1609, new constellations were created and we began to look deeper into the structure of the heavens, and to the secrets it held to our own human meaning and purpose.

This search has gone on to our current generation, when space travel took us on a quantum leap in the exploration of our universe. In this search outward, a curious thing happened. We began to look back at ourselves. For the first time we saw the earth whole and from the outside. This new perspective has perhaps done as much to alter our view of ourselves and our home planet as the outward exploration that gave us this view.

Now that we have had several years to look at ourselves, we are just starting to substantively answer the question "What is it that we see?"

Using our intuitive design

skills we have begun to answer this question. Using nocturnal satellite images we have discovered earthly constellations. The stars of these constellations are the illuminations of our urban systems. In the dark interior of our urban constellations lie our rural regions, the sources of much physical and sensory sustenance for the surrounding constellation systems.

This view of our urban systems as constellations has greatly altered our view of how urban systems should be perceived and managed. Urban constellations offer logical units for regional action. This view offers a substantial key to arousing public and professional understanding of the region as an important working scale. The following plates are examples of urban constellation patterns as viewed from nocturnal satellite photography.

By identifying all counties that are bright at night from satellite imagery we have discovered 23 urban constellations. The 1980 cenus population estimates for these counties indicate that 80% of the American public live within these 23 constellations. When comparing the 1970 and 1980 census estimates we were also surprised to see that all 23 constellations gained population over the last ten years. When one is aware of the vast losses of people from central cities in the Northeast and Midwest (one-half million from central Chicago, etc.) over the last ten years, one would have guessed at constellation loss. On further examination we discovered that practically all of the loss in

central cities is more than made up in suburban sprawl which lies within the boundaries of the identified constellations. The sunbelt constellations had the most dramatic increases, but all constallations <u>continue to grow</u> by various rates.

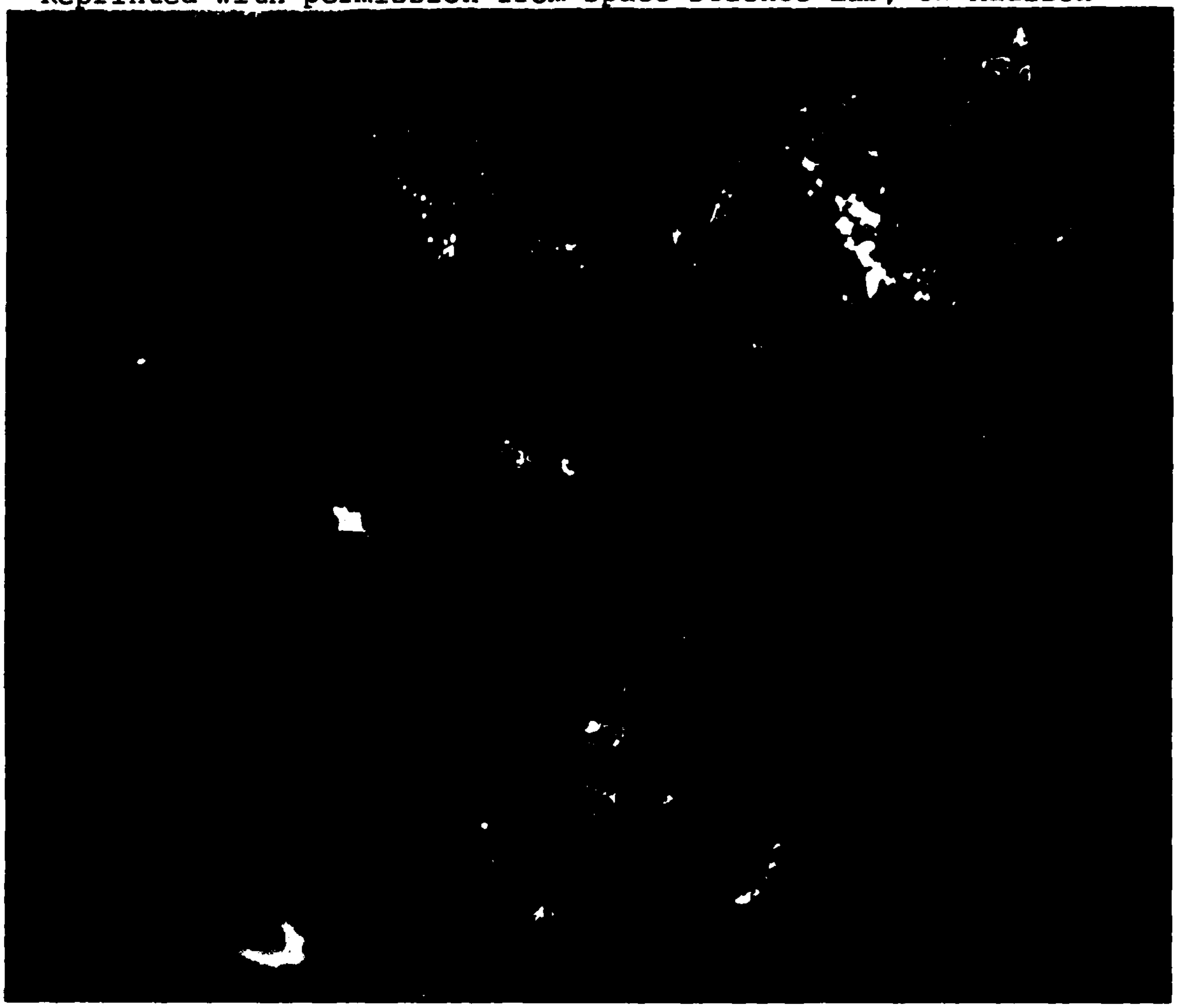
Composite Satellite Picture of Europe at Night — February 1979

Reprinted with permission from the Space Science Lab, UW-Madison

Orbits 12693-12696

Composite Satellite Picture of Africa and the Middle East at Night — February 1979

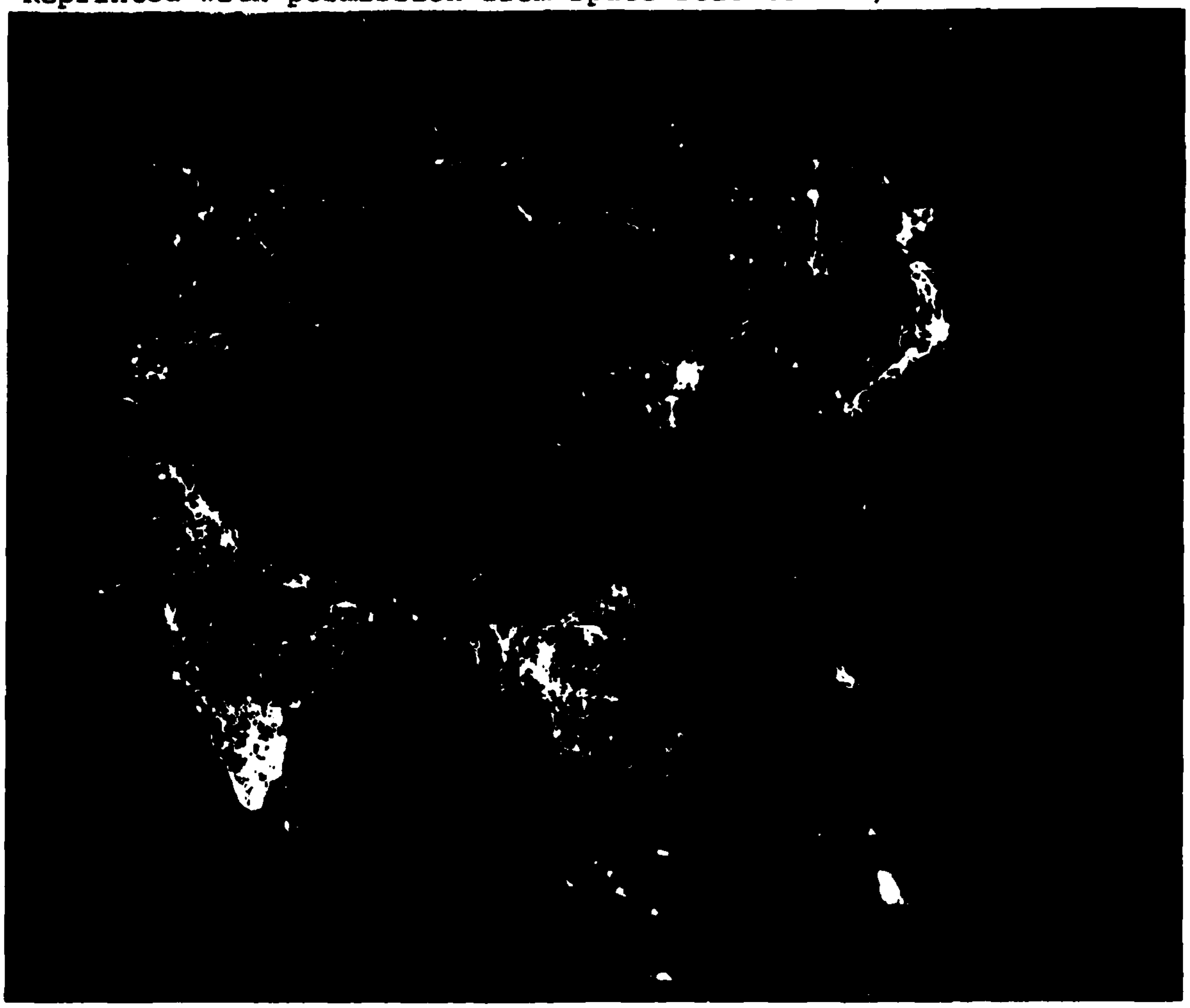
Reprinted with permission from Space Science Lab, UW-Madison



Orbits 1816-1819

Composite Satellite Picture of Asia at Night — February 1979

Reprinted with permission from Space Science Lab, UW-Madison



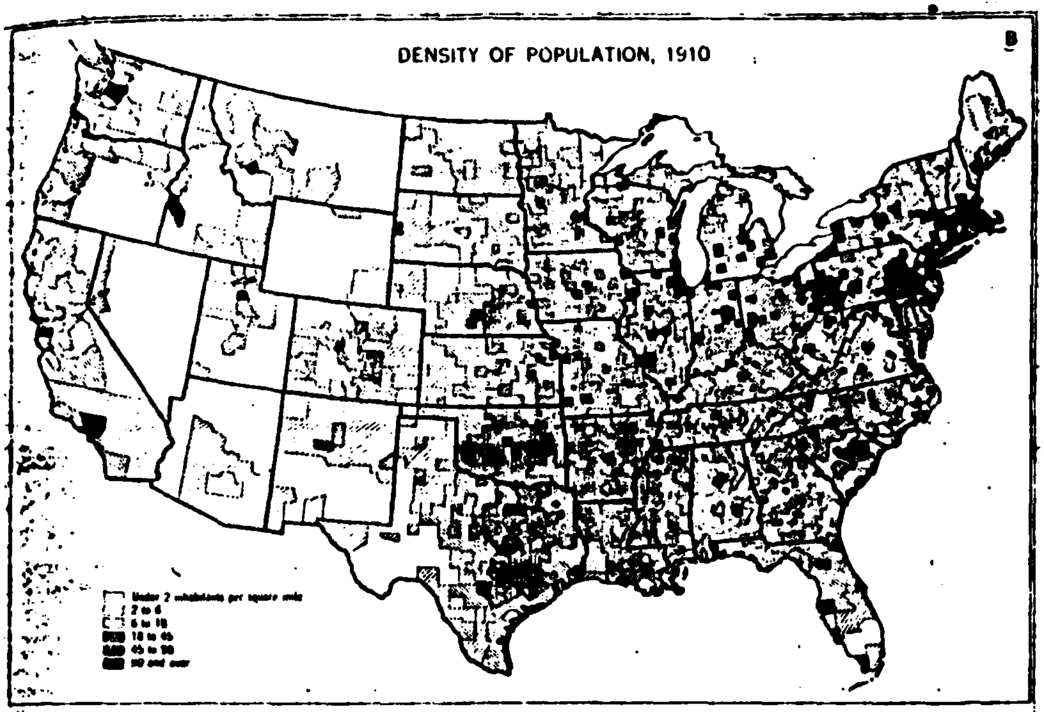
Orbits 12704-12706

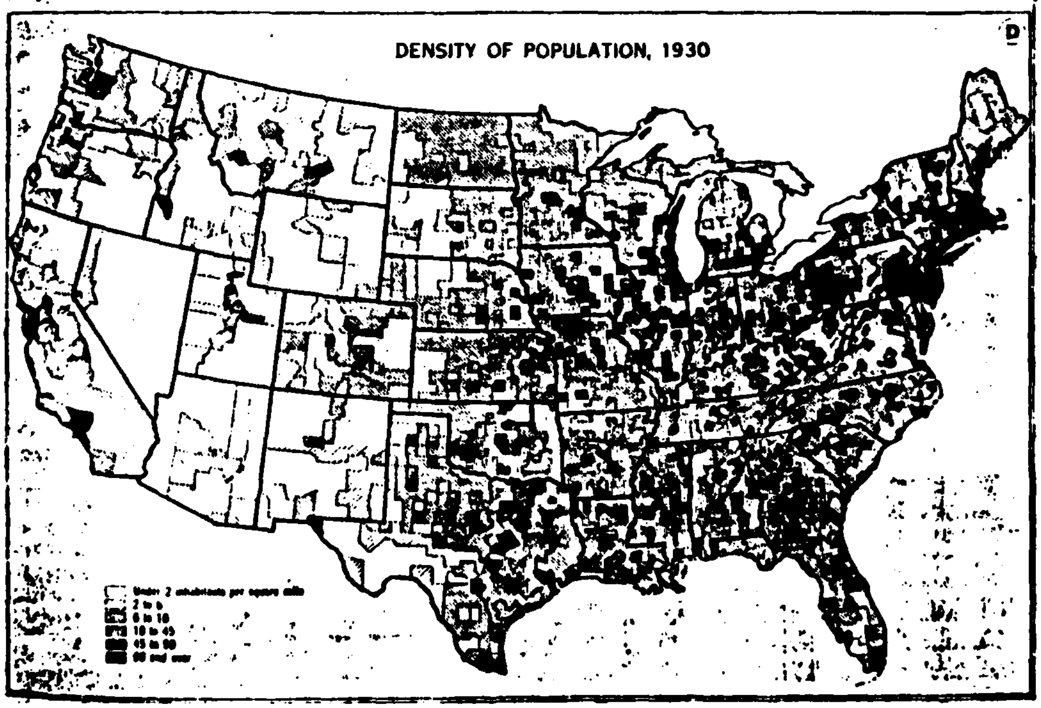
Composite Satellite Picture of South America at Night — February 1979

Reprinted with permission from Space Science Lab, UW-Madison

Orbits 12696-12698

Reprinted with permission from Carnegie Institution of Washington, Atlas Historical Geography of the United States.





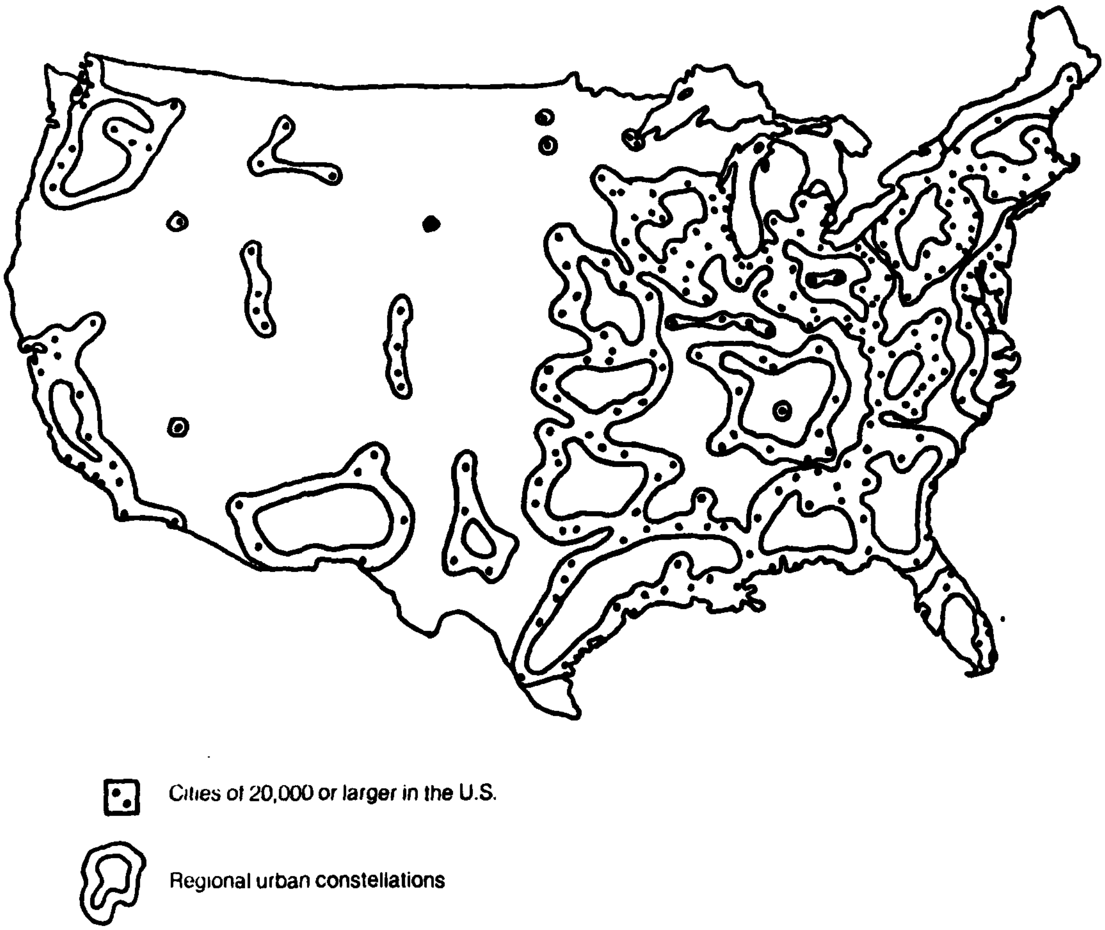
Composite Satellite Picture of the United States at Night — February 1979

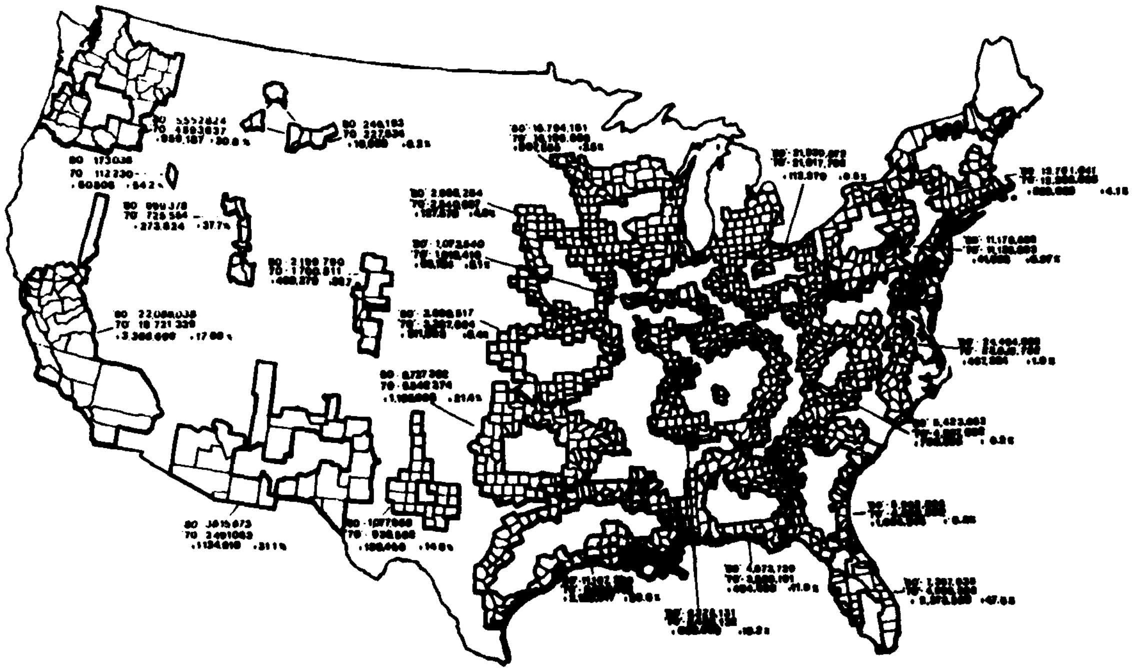
Reprinted with permission from Space Science Lab, UW-Madison

Orbits 8813-8815

Cities of 20,000 or Larger in the United States

United States Population Constellations





Circle City: An Upper Midwest Urban Constellation

The United States contains a broad array of urban constellations. Many of them are part of the massive megalopolis pattern that flows from the eastern seaboard. In our home territory, the Upper Midwest, we have identified our own constellation lying at the western front of the megalopolis pattern. We call this pattern "Circle City."

This Circle City constellation ranges from Chicago to Milwaukee, up the Fox River Valley, across central Wisconsin to the Twin Cities, down the Cedar River and across northern Illinois back to Chicago. Circle City contains over 15 million people. It contains cities growing formlessly. Southeast Wisconsin, Circle City's area of most rapid growth, also contains its richest farmland. By portraying these regional growth patterns as one system--Circle City--people are beginning to understand the need to view their local actions within a regional context.

Within the Circle City constellation lies the Driftless Area. The Driftless Area is a unique geologic region located primarily in southwest Wisconsin, with part of it spilling over into Illinois, Iowa and Minnesota. Roughly the size of the state of Vermont, the Driftless Area was bypassed by the last glacial movement. In contrast to the young landscape around it, the Driftless Area has been weathering and wearing for at least 250,000 years, more than ten times longer than the rest of the state's surface.

The growth of Circle City has begun to surround the Driftless Area with a human glacier. Until Circle City is controlled and given meaningful form, the desire to escape it will grow. People will look to the Driftless Area as a place to both visit and live. Just as the flight from overcongested city centers has produced the sprawling suburb, the flight from Circle City threatens the values of the rural regional landscape.

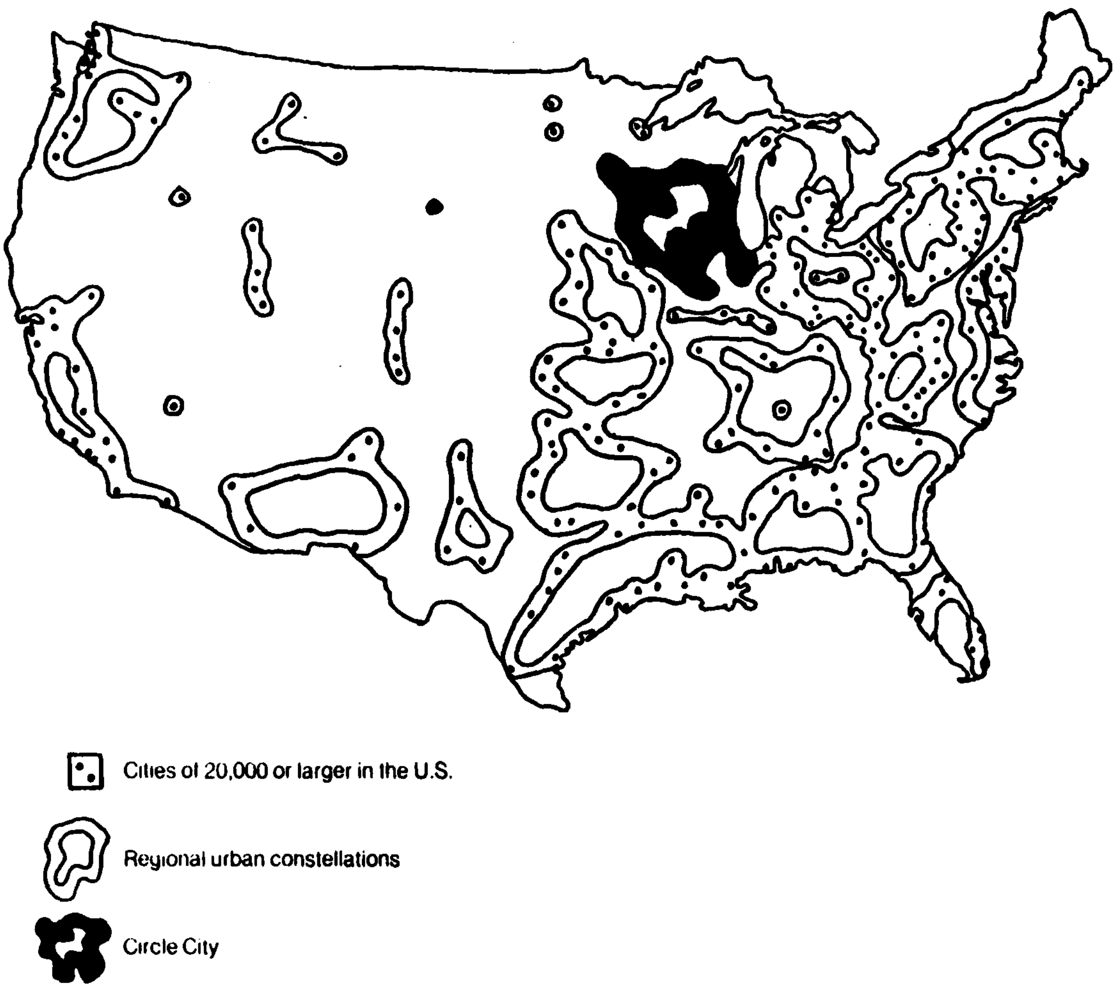
Therefore, the Environmental Awareness Center has taken on the task of designing the landscape of the Upper Midwest, from the rural township to the inner core of the metropolis, all within the matrix of the evolving Circle City pattern--a Sketch Plan for Circle City. It focuses on our regional landscape in an exploration of ways that economic, social, cultural and ecological standards of living can grow in equal balance for the region's people.

The following plates represent some of the initial analysis we have conducted of the Circle City region. These plates provide a partial basis for creating a practical vision of the future of Circle City.

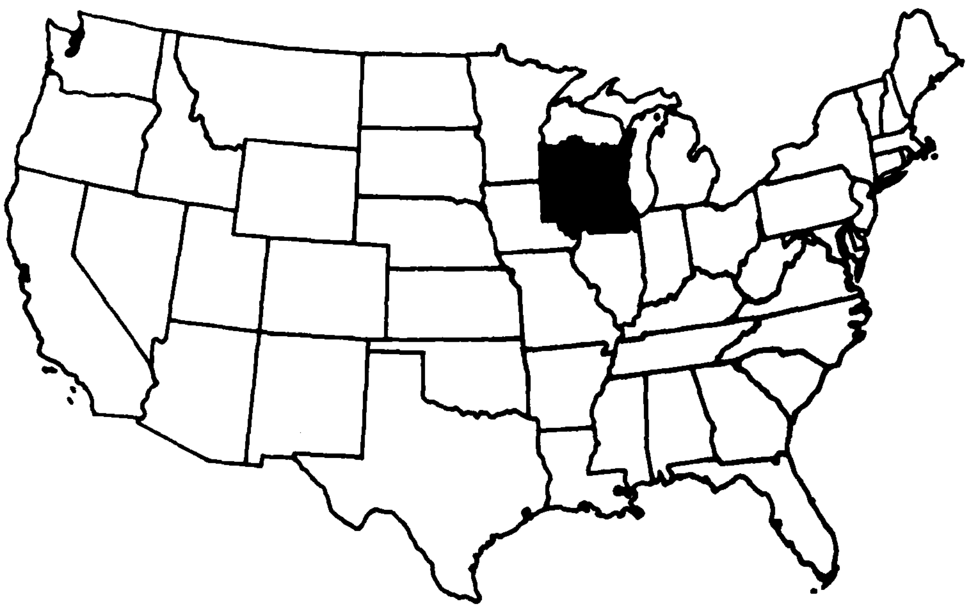
As a prototype for the 23 constellations in determining changing populations, housing, land use controls, housing types, housing starts and consequently wood needs, we focused on our own upper Midwest Constellation that we call Circle City.

Briefly, the following plates reveal a constellation of 16,196,606 people in 1970 and a population of 16,794,161 in 1980. This represents an increase of 597,555 people or an increase of 3.5% between 1970 and 1980. In working with Dr. Paul Voss in the University of Wisconsin Department of Rural Sociology we have been able to project a population of 17,924,870 in 1990 and a population of 19,597,070 people in the year 2000 reflecting a percentage growth of 6.7% between 1980 and 1990 and a percentage growth of 9.3% between 1990 and the year 2000, both substantially greater than the growth from 1970-1980 of 3.5%.

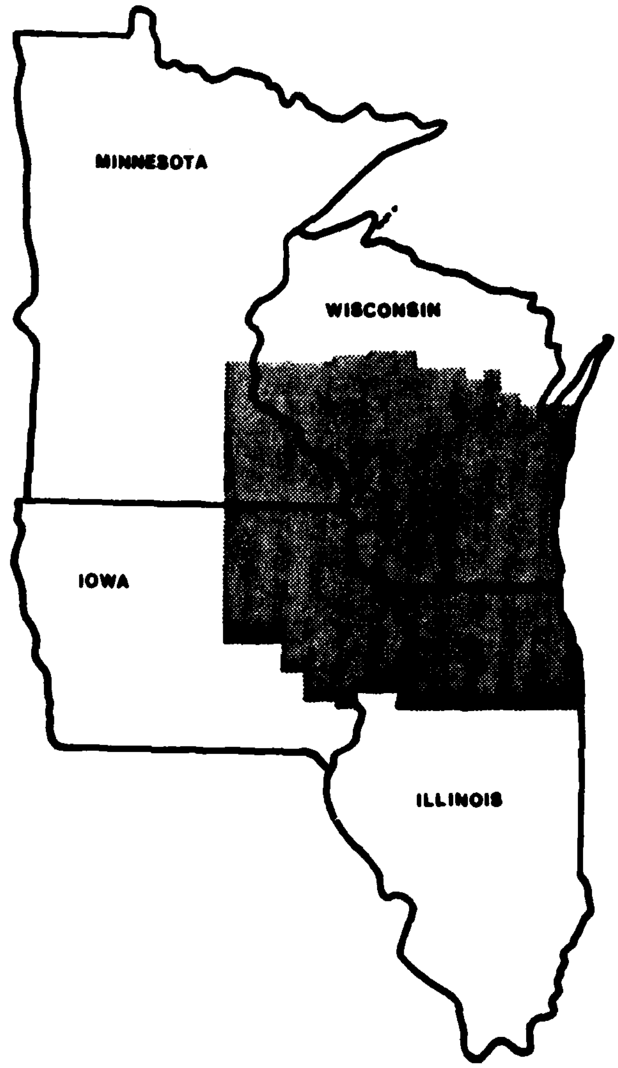
Population Centers of the United States



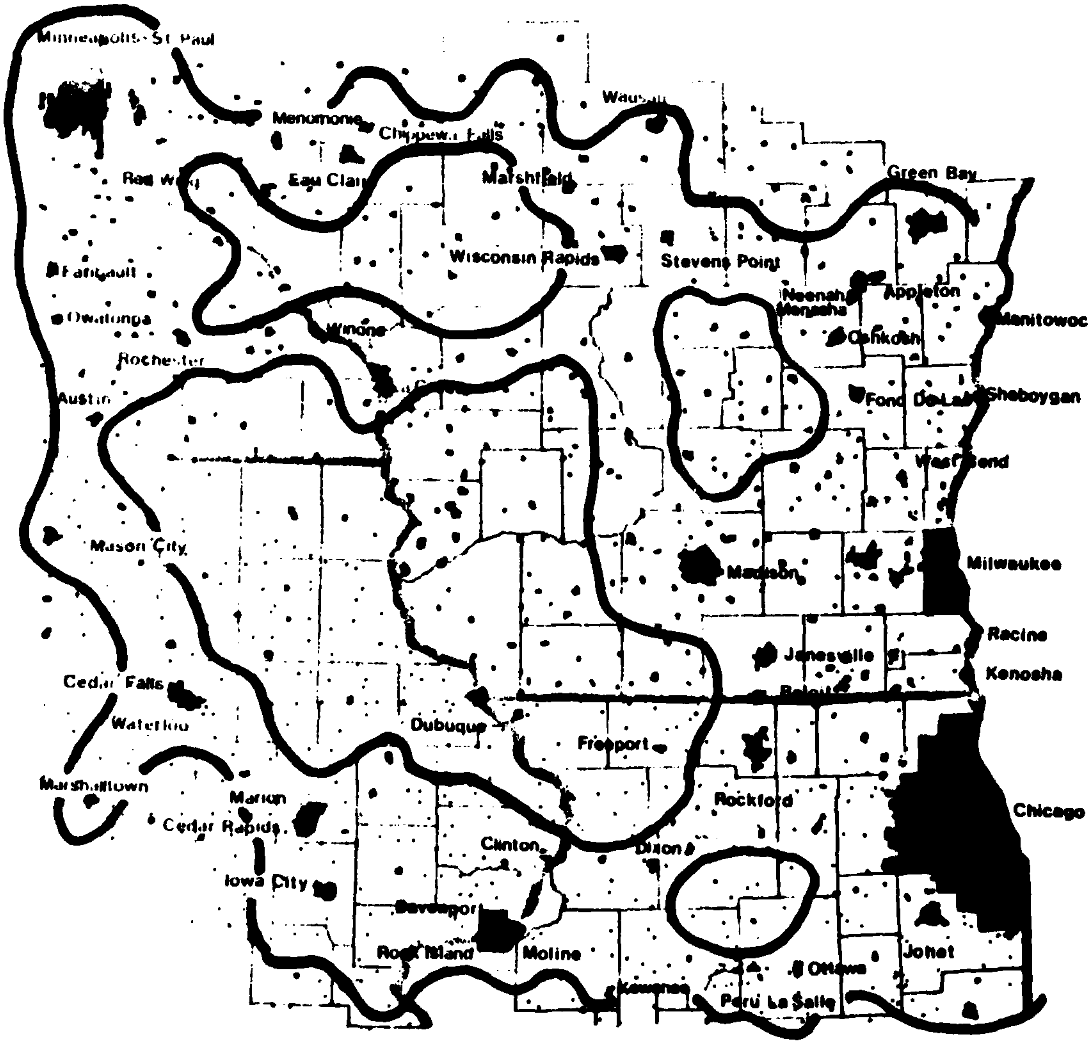
A National Perspective of Circle City



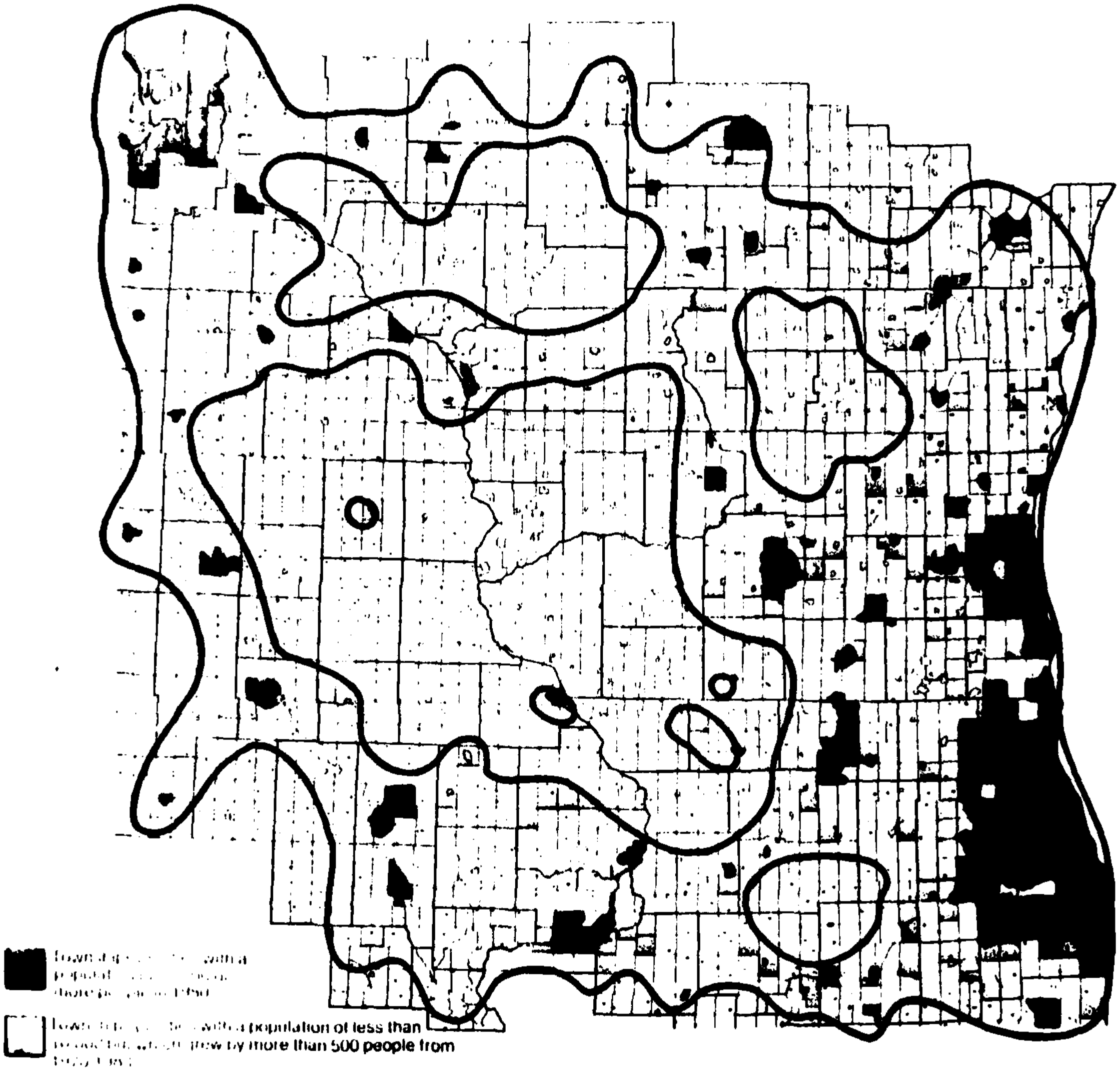
A Midwestern Perspective of Circle City



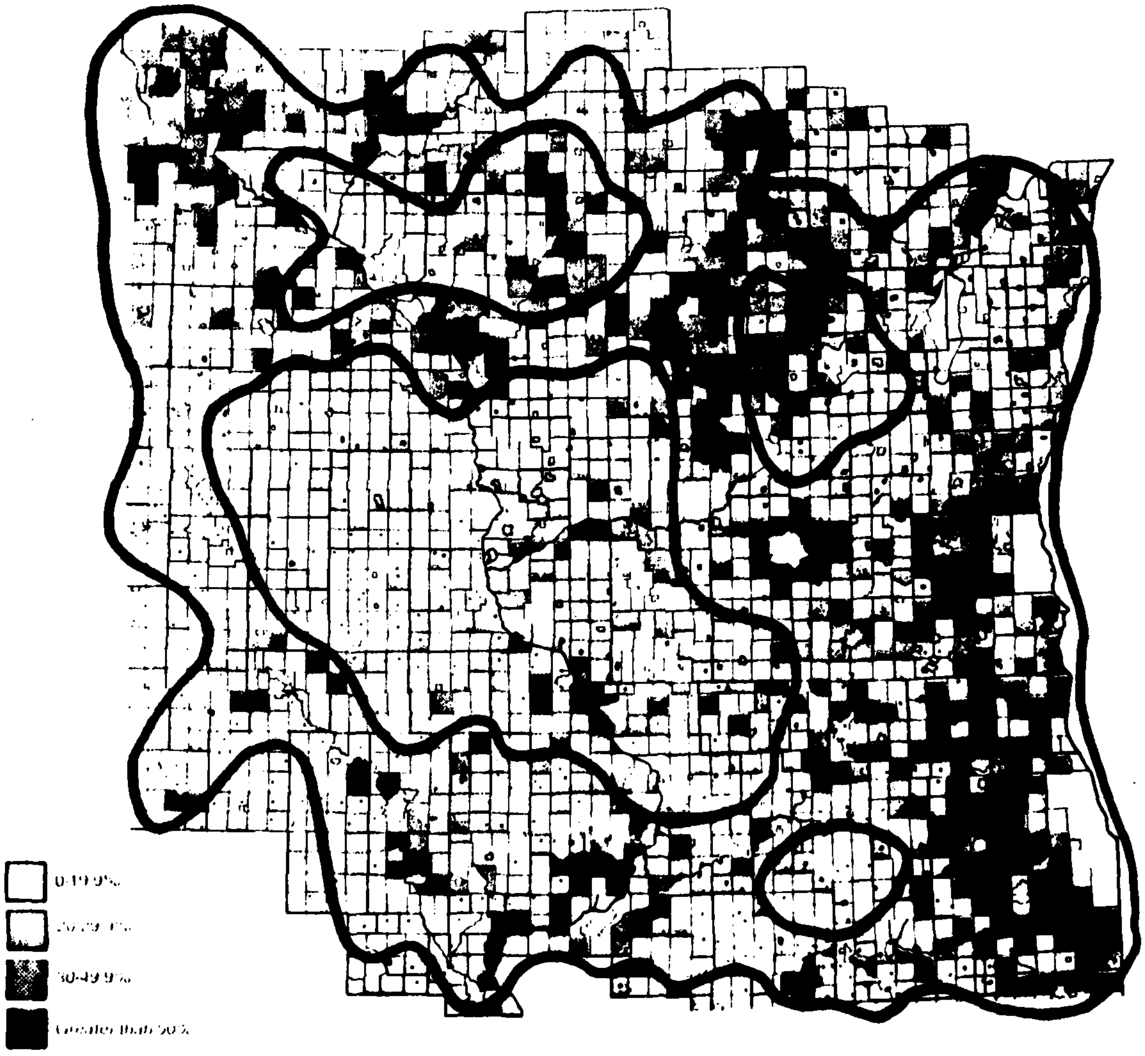
Primary Cities in the Circle City Region

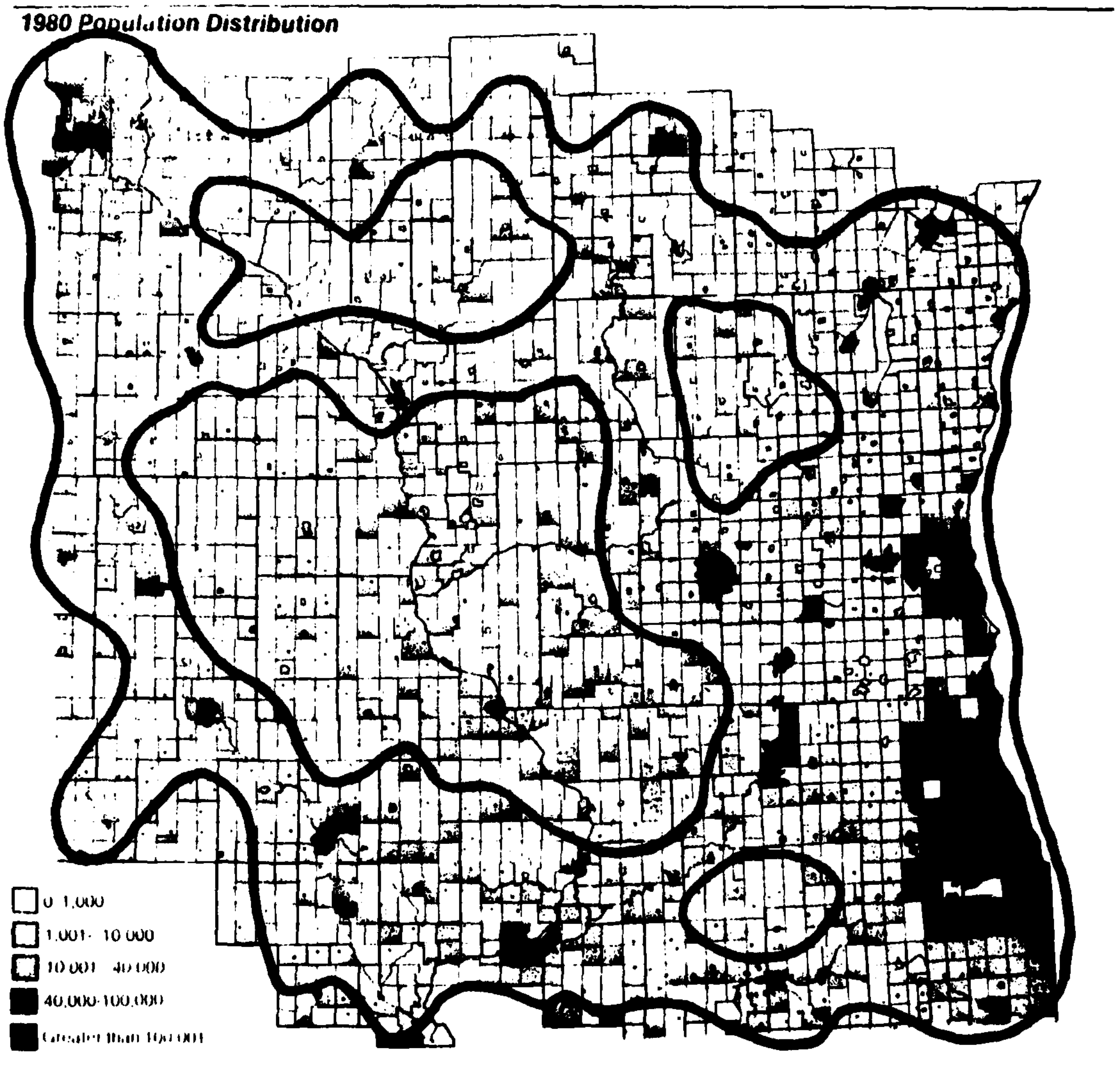


The Circle City Population Pattern

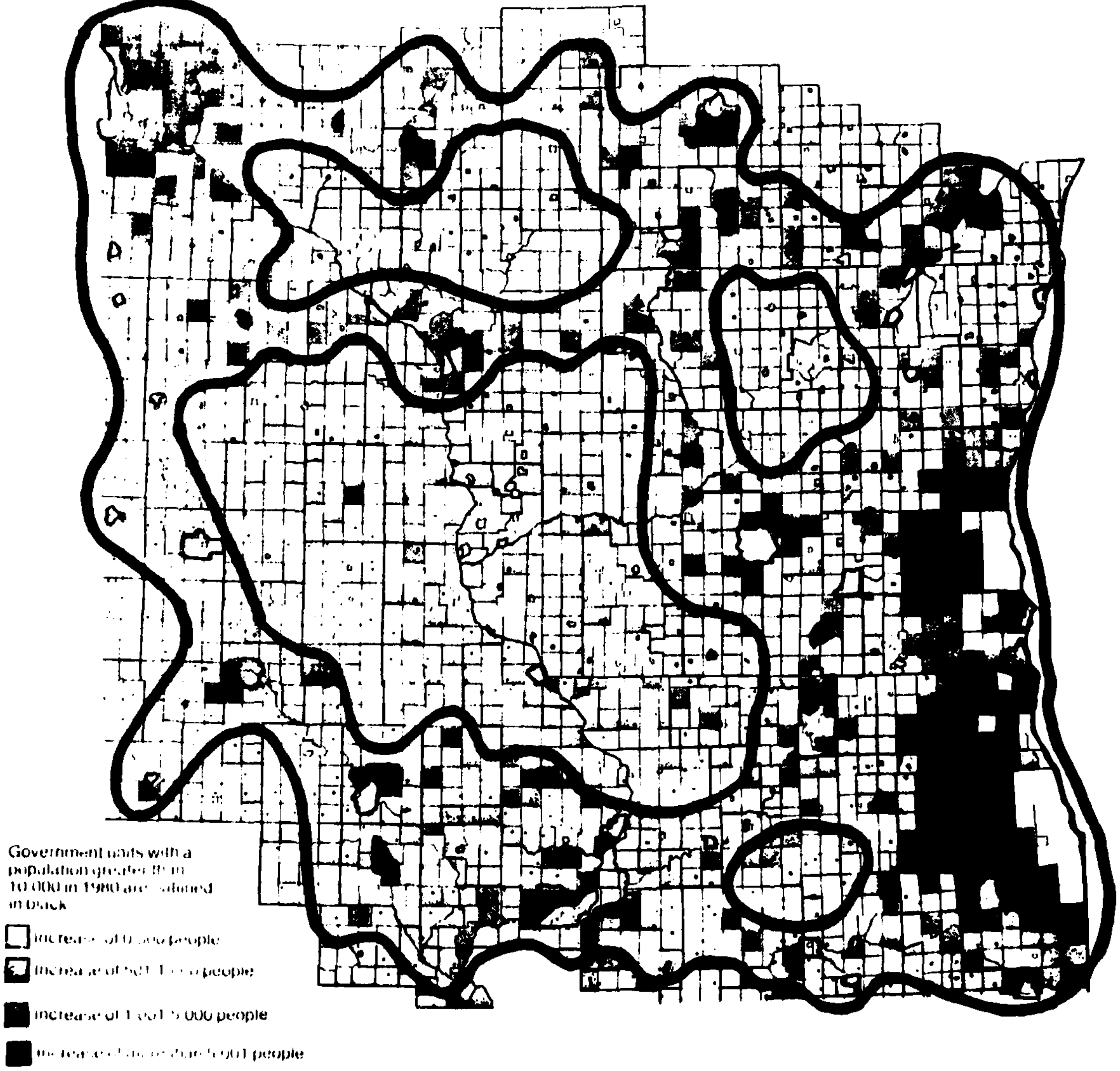


***The Human Glacier:* Percent Increase in Population 1970-1980**

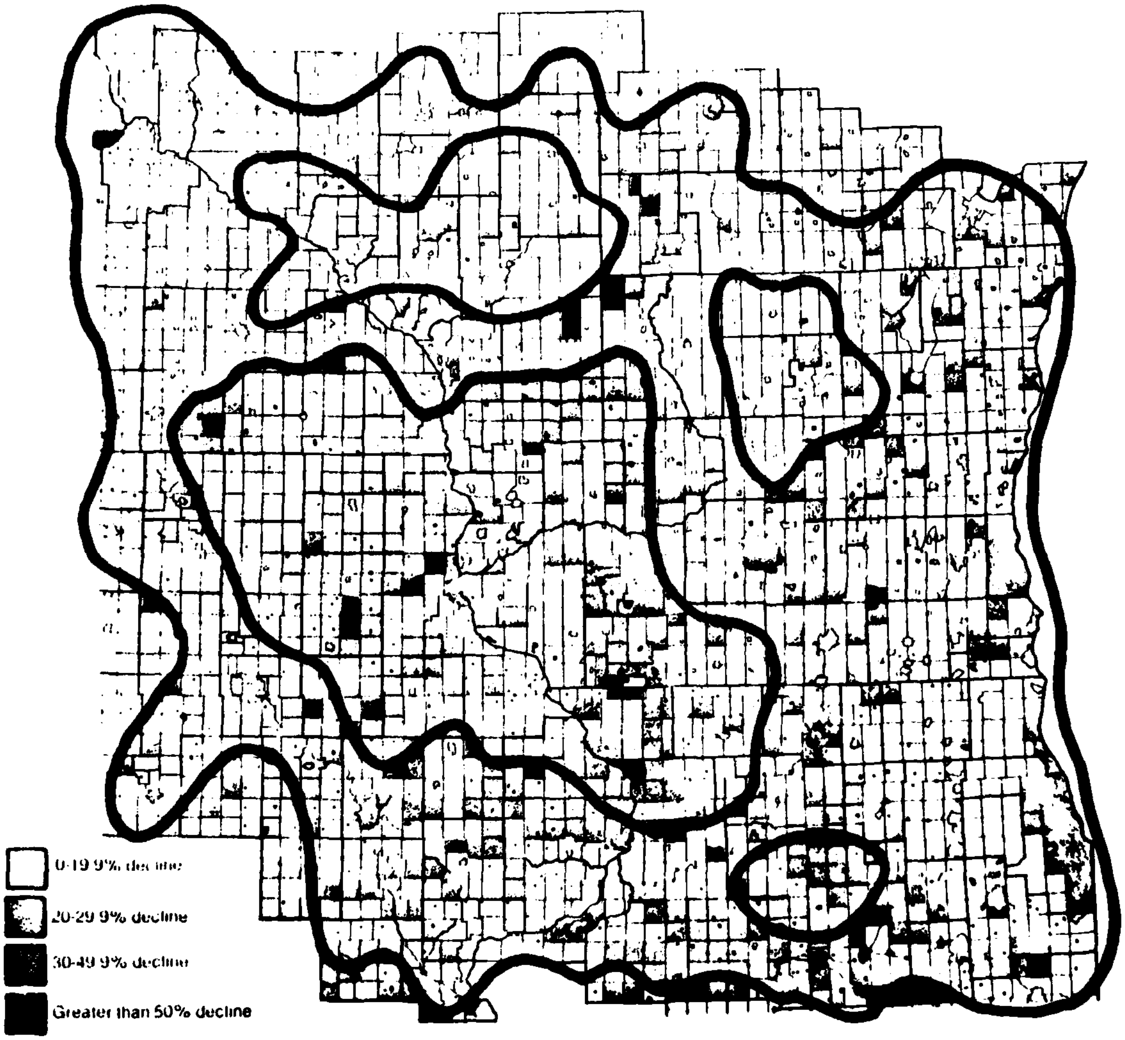



1980 Population Distribution
0 1,000
1,001- 10 000
10 001 40 000
40,000-100,000

Growth of the Suburbs

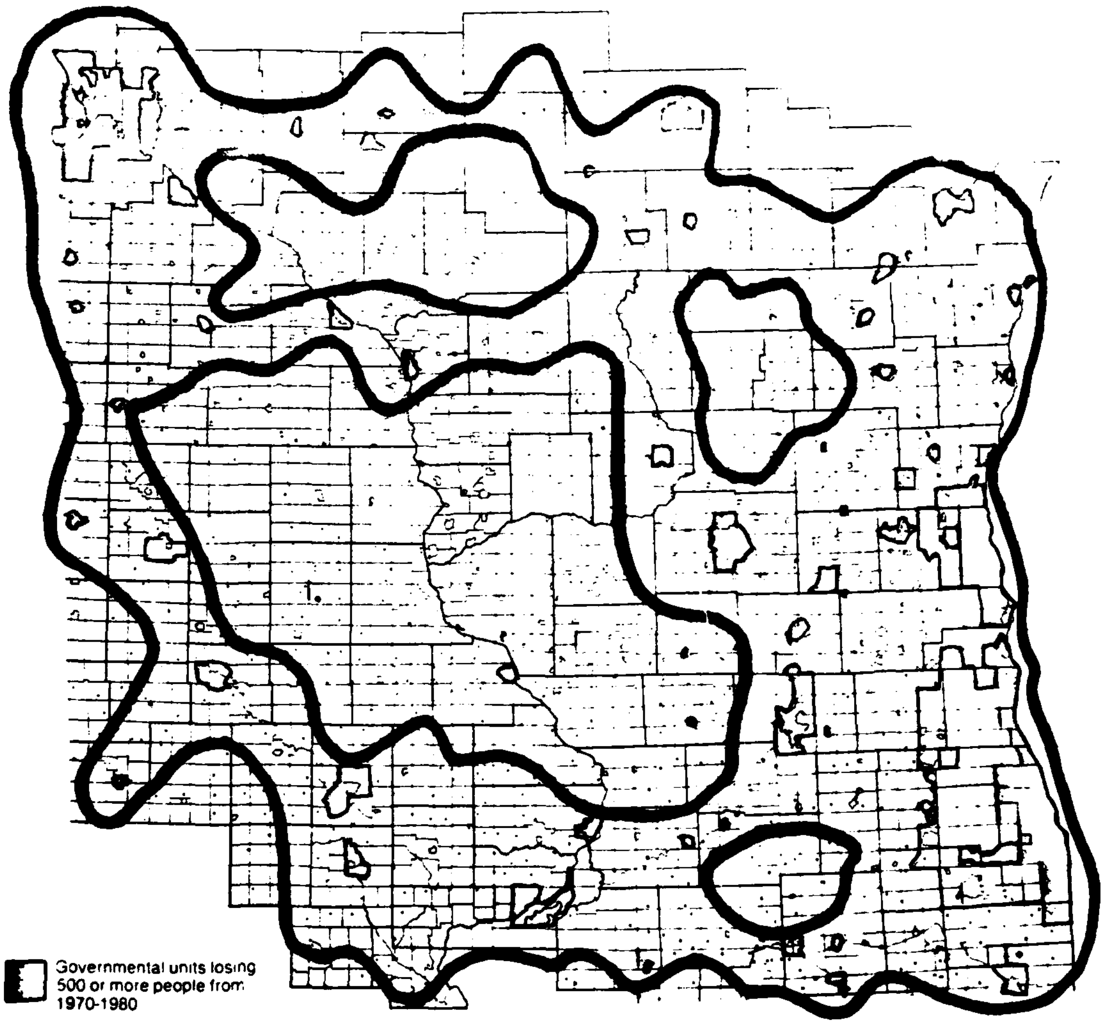


Percent Decline in Population (1970-1980)

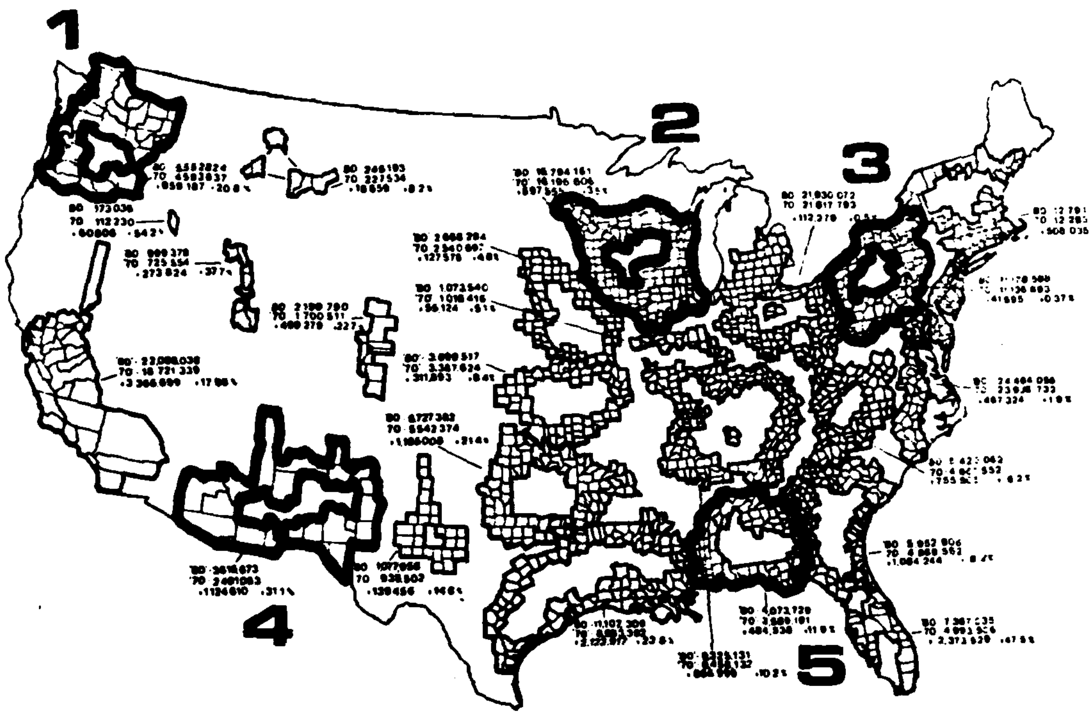


All white areas showed an increase in population

The Decline of Our Central Cities (1970-1980)



Governmental units with a population over 10,000 in 1980 are outlined



	1970	1980	1990	2000
1. Northwest Constellation	20.8%	17.1%	14.5%	Down
2. Midwest Constellation	3.5%	6.7%	9.3%	Up
3. Northeast Constellation	.37%	1.7%	3.47%	Up
4. Southwest Constellation	31.1%	35.8%		Up
5. Southeast Constellation	11.9%	7.52%		Down

Population Projections

Constellation	1980 Census Total	1990 Projection	1980-1990 Percent Increase	2000 Projection (if data exists)	1990-2000 Percent Increase
1. NORTHWEST* States: Oregon Washington	5,555,824	6,506,714	(1970-1980 increase 20.8%) 17.1152%	7,451,254	14.5164%
2. MIDWEST* States: Illinois Iowa Minnesota Wisconsin	16,794,161	17,924,870	(1970-1980 increase 3.5%) 6.7328%	19,597,070	9.3289%
3. NORTHEAST* States: Maryland New York Pennsylvania West Virginia	11,178,598	11,370,773	(1970-1980 increase .37%) 1.7191%	11,765,864	3.4746%
4. SOUTHWEST* States: Arizona New Mexico Texas	3,615,673	4,911,595	(1970-1980 increase 31.1%) 35.8418%	____ (no data for Mexico)	____
5. SOUTHEAST* States: Alabama Florida Georgia Mississippi	4,073,729	4,380,284	(1970-1980 increase 11.9%) 7.5252%	____ (no data for Georgia)	____

*Portions of States

Data obtained from Population Lab, UW-Madison

THE WALL STREET JOURNAL

PAGE 35
TUESDAY, OCTOBER 12, 1982

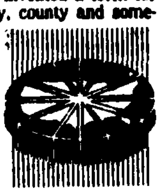
REGIONS

Soon MSA, PMSA and CMSA Will Replace Good Old SMSA

By EUGENE CARLSON
Staff Reporter of THE WALL STREET JOURNAL

IMAGINE YOU'RE APPROACHING New York City by air on a clear night. Look out the window. The sea of light below spills far beyond the city proper; into New Jersey, Connecticut and over much of Long Island. This is more than a big city, more even than a metropolitan area. What do you call this sort of runaway urban landscape?

More than 30 years ago, the government invented a term for urban areas that sprawl willy-nilly across city, county and sometimes state boundaries. It called them Standard Metropolitan Statistical Areas. Over the years, the SMSA has become a benchmark for collecting and publishing census and economic data. It defines what communities qualify for certain government funds. It's a basic tool for marketing executives and others who mine Census Bureau publications for their industrial raw material.



(Basically, an SMSA is a county, or counties, with an urban population of more than 50,000. There are 323 SMSAs in the U.S. and Puerto Rico.)

As urban areas have mushroomed, many feel the SMSA concept has become statistically passe. It embraces too much. "When you have to accommodate more than 300 areas all over the country, it makes the rules more complicated than they otherwise might be," says Richard L. Forstall, a Census Bureau analyst. Los Angeles-Long Beach, Calif., (pop. 7.5 million) and Lake Charles, La., (pop. 167,000) are both SMSAs. What else do they have in common?

FEDERAL OFFICIALS have considered the problem. And government being government, the answer was obvious. Make more categories. In December, the Office of Management and Budget will release the first part of the revised urban roster.

Pay attention, now. Under the new scheme, the urban behemoths—New York, Chicago, Los Angeles and perhaps 25 more—will be known as Consolidated Metropolitan Statistical Areas, or CMSAs. Major urban areas inside the CMSAs (for example, Nassau and Suffolk counties on Long Island, now an SMSA of its own) will be called Primary Metropolitan Statistical Areas, or PMSAs. And urban areas that stand alone, such as Lake Charles, Syracuse, N.Y., or Sheboygan, Wis., will be called Metropolitan Statistical Areas, or MSAs. The term SMSA will disappear.

One result will be lots more statistics. "To provide useful figures for big-city geography, you really have to provide two sets of data," says Mr. Forstall. For example, data users will be able to get government population and economic figures for the New York City CMSA, which will cover parts of three states, as well as for the urban areas within: New York City, Long Island, Newark, N.J., Stamford, Conn., and so on.

For the past 12 years the Environmental Awareness Center has been focusing on Regionalism and the importance of understanding the uniqueness of each region. We have recognized the importance of regional population density patterns and welcomed the Wall Street Journal article declaring a replacement for the "good old SMSA." It is obvious that we can no longer look only at single cities or the current sprawling Standard Metropolitan Statistical Area (SMSA) designation, but must accept the true regional patterns of people in what we call constellations.

By looking at each regional constellation we will in the future identify the uniqueness of building materials, a skilled labor force, transportation options, available capital, unique ethnic needs and regional research that will more precisely predict the need for wood on a national scale. Growth in the future will depend on the carrying capacity of each unique region.

Circle City Landscape

A major growth factor for any constellation will depend upon whether the constellation has adequate quantities of clean water, clean air, productive soils, forests, woodlots, natural and cultural diversity, and liveable cities. The following plates in the Landscape Analysis and many other studies by the Environmental Awareness Center have indicated that Circle City is well endowed with these basic resources and if managed properly should have little trouble sus-

taining its present and projected growth. Constellations not possessing these critical resources may expect a down turn in their growth rate as reflected in the projections on page .

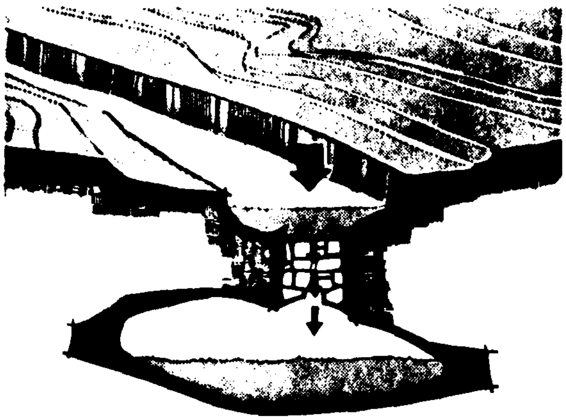
Managing these resources properly requires an intensive new look at the hundreds of acres of under-utilized urban acres within the cities of Circle City. Creative new land banking and air right use of rail and other transportation corridors can provide higher liveable density "infill" that can aid in slowing rural regional sprawl.

Springs constitute the beginning of a flow of fresh water from the *earth joining and emptying into larger bodies of water.* Their freshness and clearness must be maintained as they are the beginning source of cool clean water for streams and rivers below for the probable use and consumption by man and animal.

In the streams run the sparkling clarity of clean, rushing water accompanied by refreshing sounds of nature. Spoilage of the streams by careless use destroys these regional habitats for the fish and the sport of the fisherman.

At the end of the stream we meet the river. The flowing river is filled with life and *movement and helps serve as a mirror of the world* around. A river is a resource to be viewed from above and below and whose entire course should be developed wisely for future generations.

Adjacent to the springs, streams, rivers, and lakes we may observe the wetlands. The wetlands are of value as a native environment for fish, animal, and bird life. It provides a nesting, raising, and feeding ground for many types of wildlife.



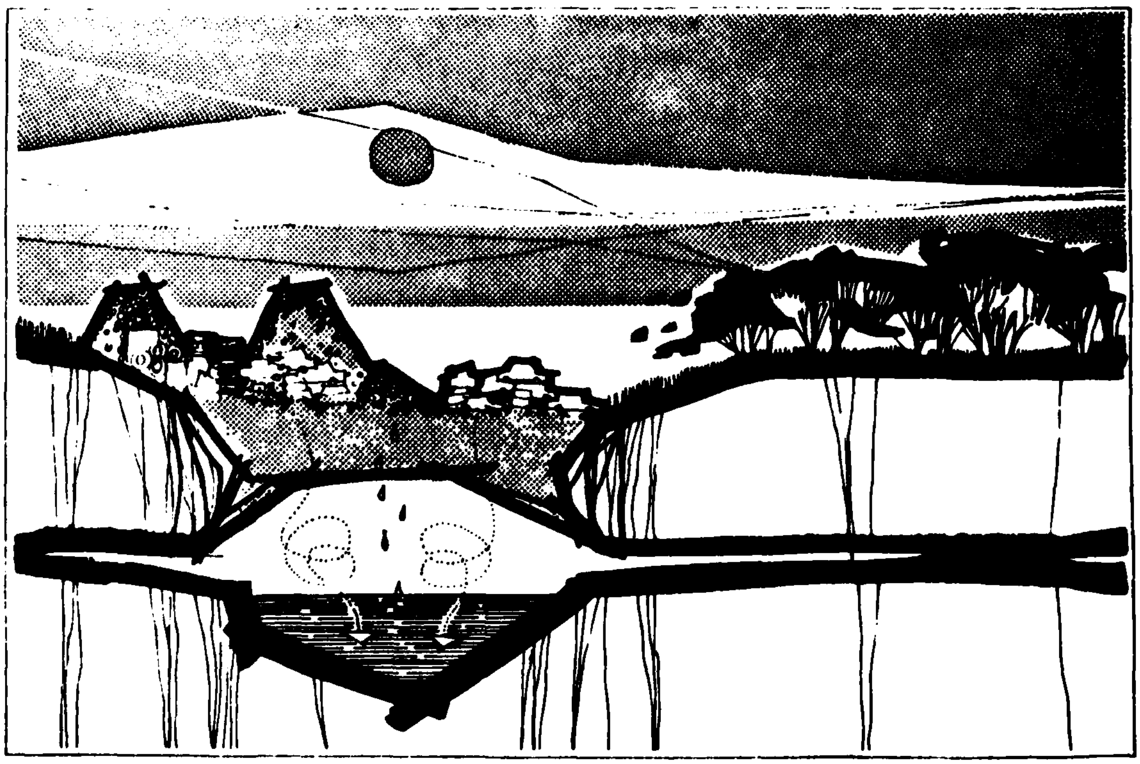
Some wetlands and certain soil types in and near our water systems provide *aquifer recharge areas.* These porous soils allow the surface water of an area to refill the underground water storage system for *future use by man. These regional patterns must be protected from* development so they can function as the natural order has planned.

Within these lowland habitats are found the birds and animals. Birds carry seeds, destroy harmful insects that would erase the plant life of the forest . . . or the food of man . . . are game for the sportsman . . . and are singers of varied songs that pierce the quiet of early morn. A surprising flash of red or blue between the tree branches.

SUB-SURFACE PATTERNS

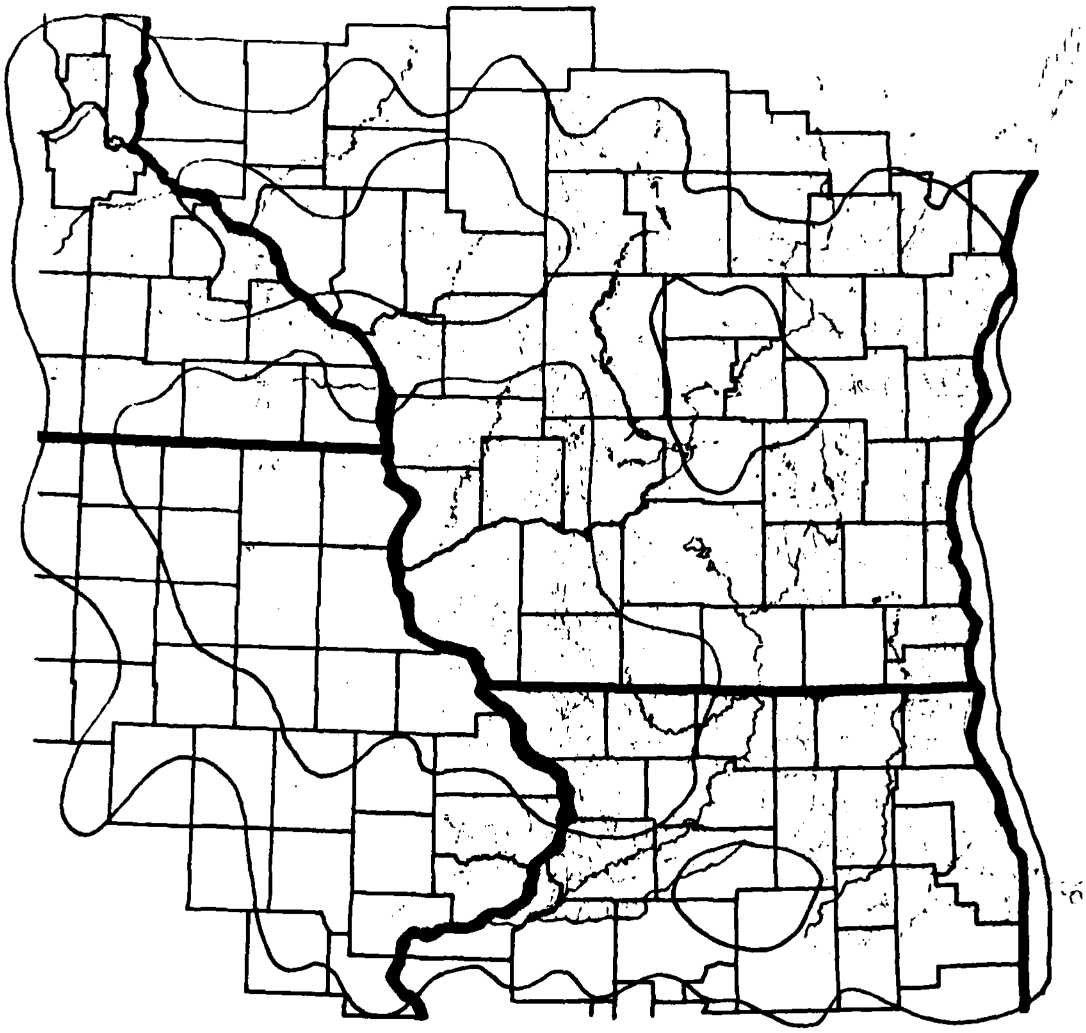
Aquifer Recharge Patterns. Within many of our landscapes we find our *aquifer recharge patterns. These are basically porous patterns that* permit our surface waters to penetrate the surface of the landscape and refill our natural underground storage systems. Protected from high density development, and assuming that we will have a normal rainfall, our underground storage systems will continue to provide drinking water for present and future generations.

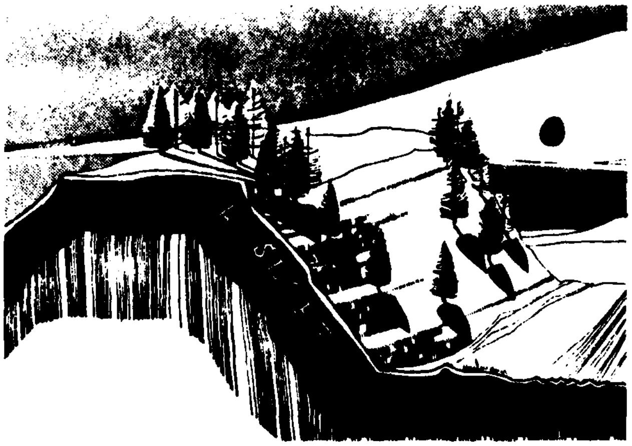
Ground Water Patterns. Geologic processes have created beneath the land's surface underground water storage systems. Since they contain much of our future water supply, it is vitally important to know where these patterns are.



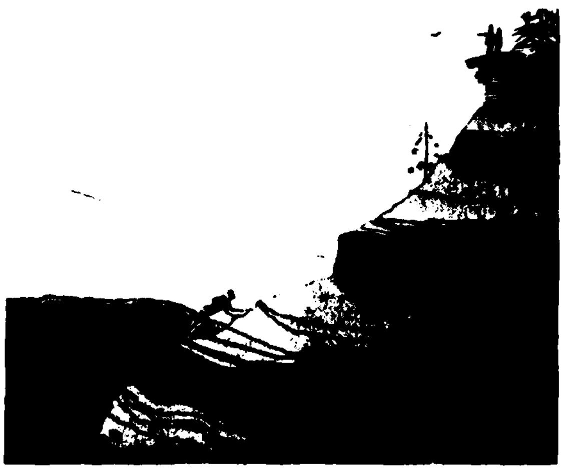
Human Waste and Disposal Patterns. Few people today, if asked, could identify where in a university or industrial community all past wastes from chemistry and research labs have been disposed. Some, no doubt, have been unwisely located above geological formations, making it possible for seepage to pollute underground water supplies. Offensive odors from such areas can also make human occupation impossible.

Water Resources



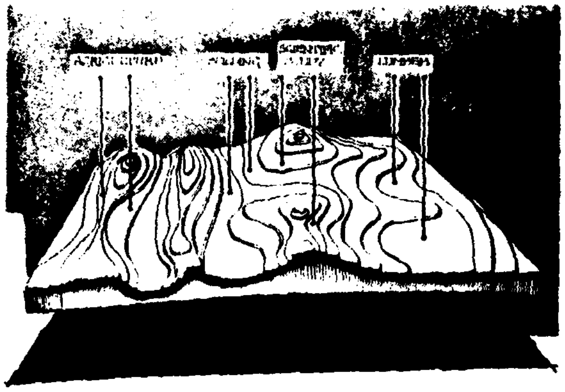


The basic landscape features that separate these ridge-tops from their valley floor are known as *slope*. There has been scientific support that the farming of slopes of over 12½ per cent often creates serious soil erosion problems.



The land may be too steep to plow, but for man it is a place to scale either *in* body or *in* mind.

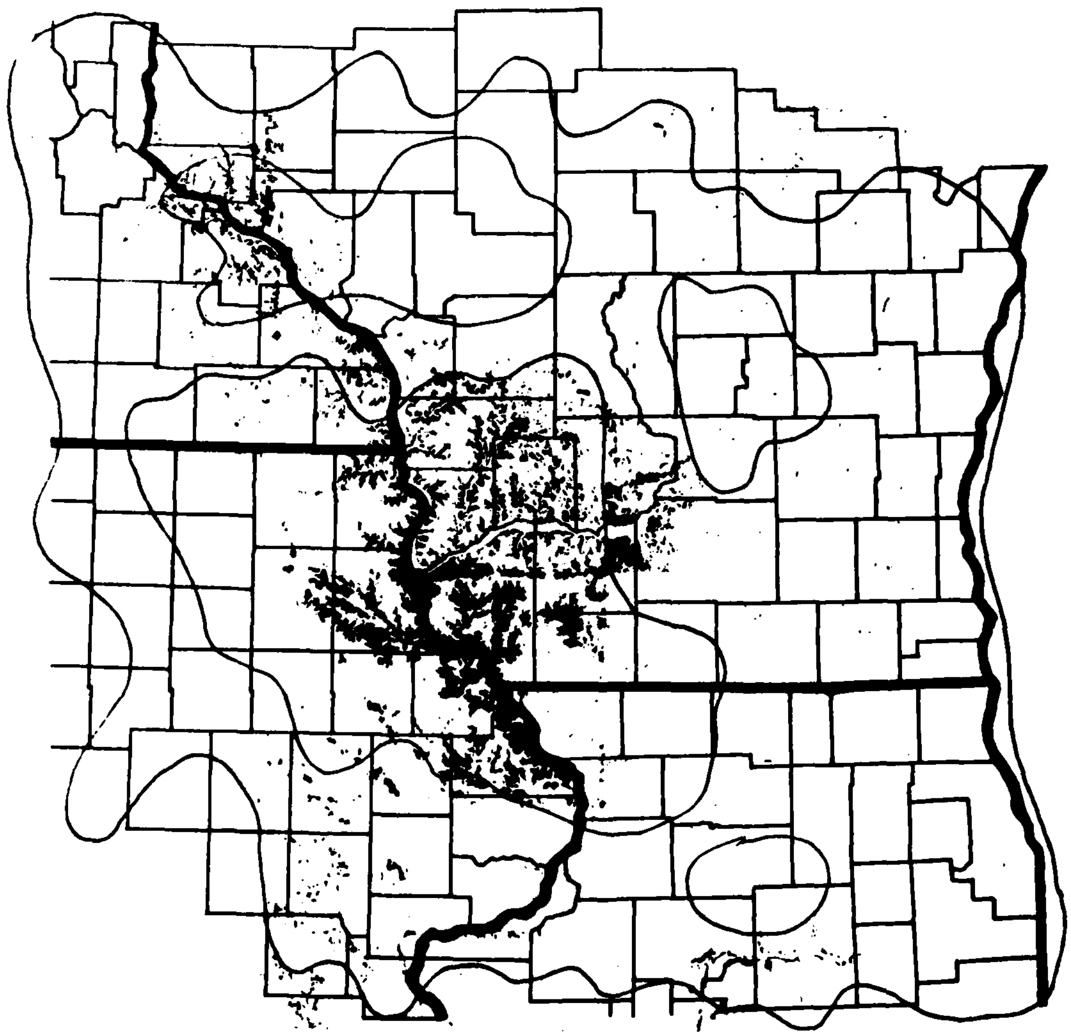
Over most of the ridges, slopes, and valley floors may be found the carpet of life giving soil. There are many soil varieties, and each is capable of supporting certain types of plant and animal life and activities of man.

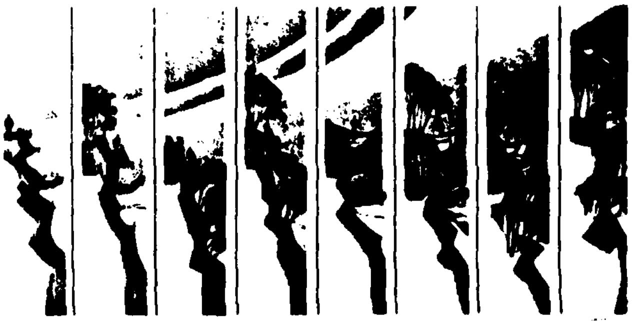


The land is a fixed quantity and it is therefore most urgent that we identify and preserve the soils for their unique qualities and usefulness, whether for agriculture, building sites, scientific uses or for sustaining such resources as water and lumber. Regional patterns of soil should well suggest and guide the preliminary form of most human development.

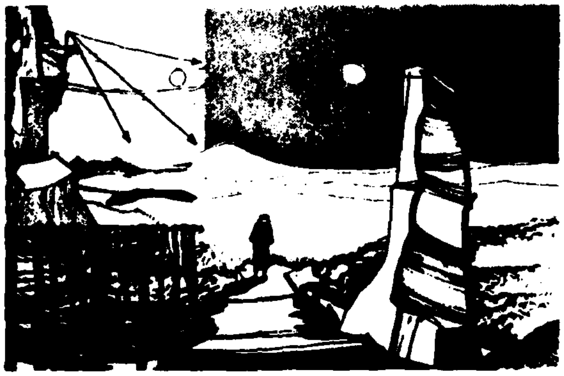
At the upper most edge of a slope we see what might be called a *rim*.

Topography With a Slope of 12½ Percent or More





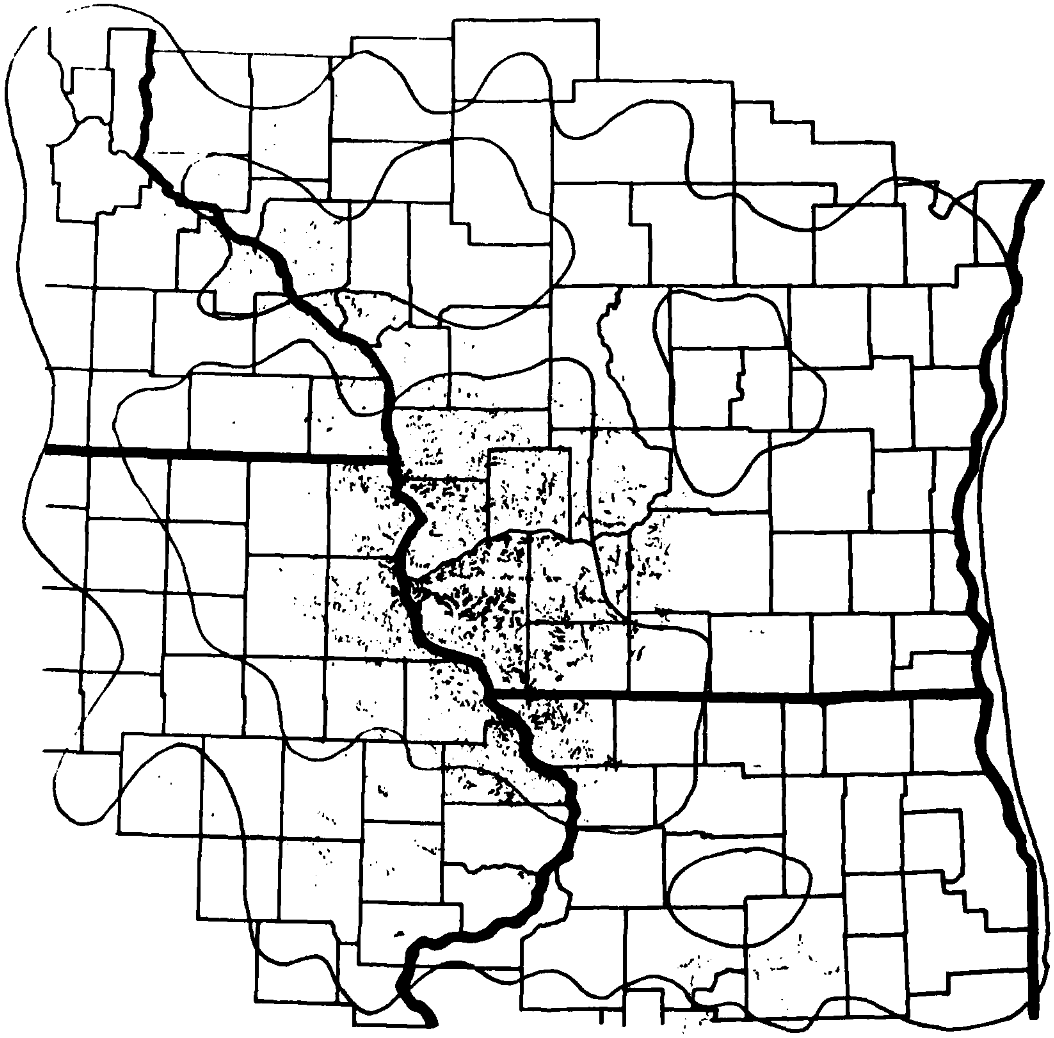
The rims often provide a pathway by foot or vehicle through an ever-changing variety of views and landscape forms — trees, slopes, and rocks. Preservation of this natural pathway along its course will allow for a sequence of visual delight. These various characteristics can be classified. In one place along the rim one may find bare rock, in another place trees below, all constituting a series of situations that provide a variety of experiences.



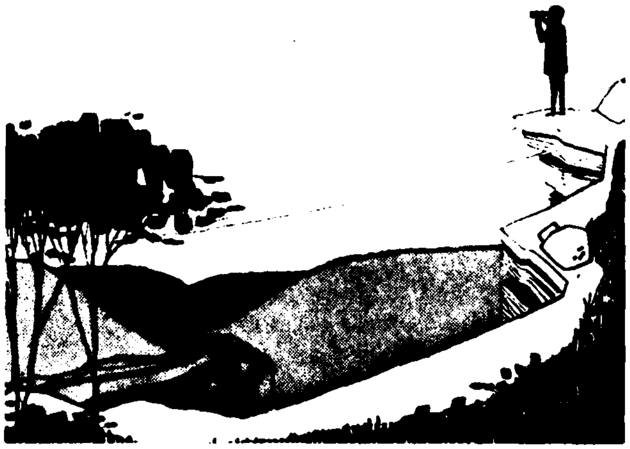
Standing on the rim, one cannot help but admire the scenery below. One may even feel exalted with a feeling of superiority or have a sense of fear and danger to be viewing the panorama from such a high vantage point.

Too much of the same pattern can result in visual monotony. The designer must impartially inventory and record those assets and liabilities of the site with which he must work if he is to design a human walkway containing interest and variety.

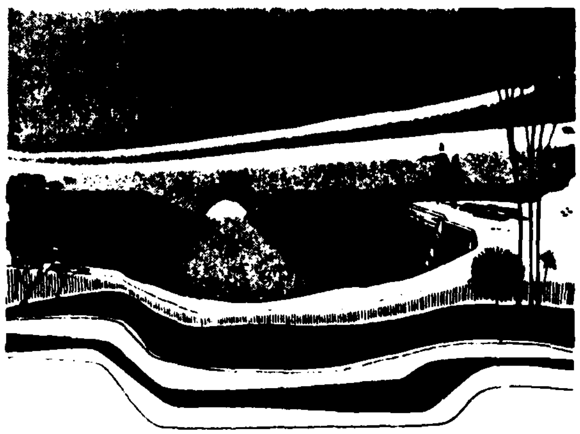
Rims* in the Driftless Region



*Rims are the uppermost edge of a slope and provide natural observation platforms

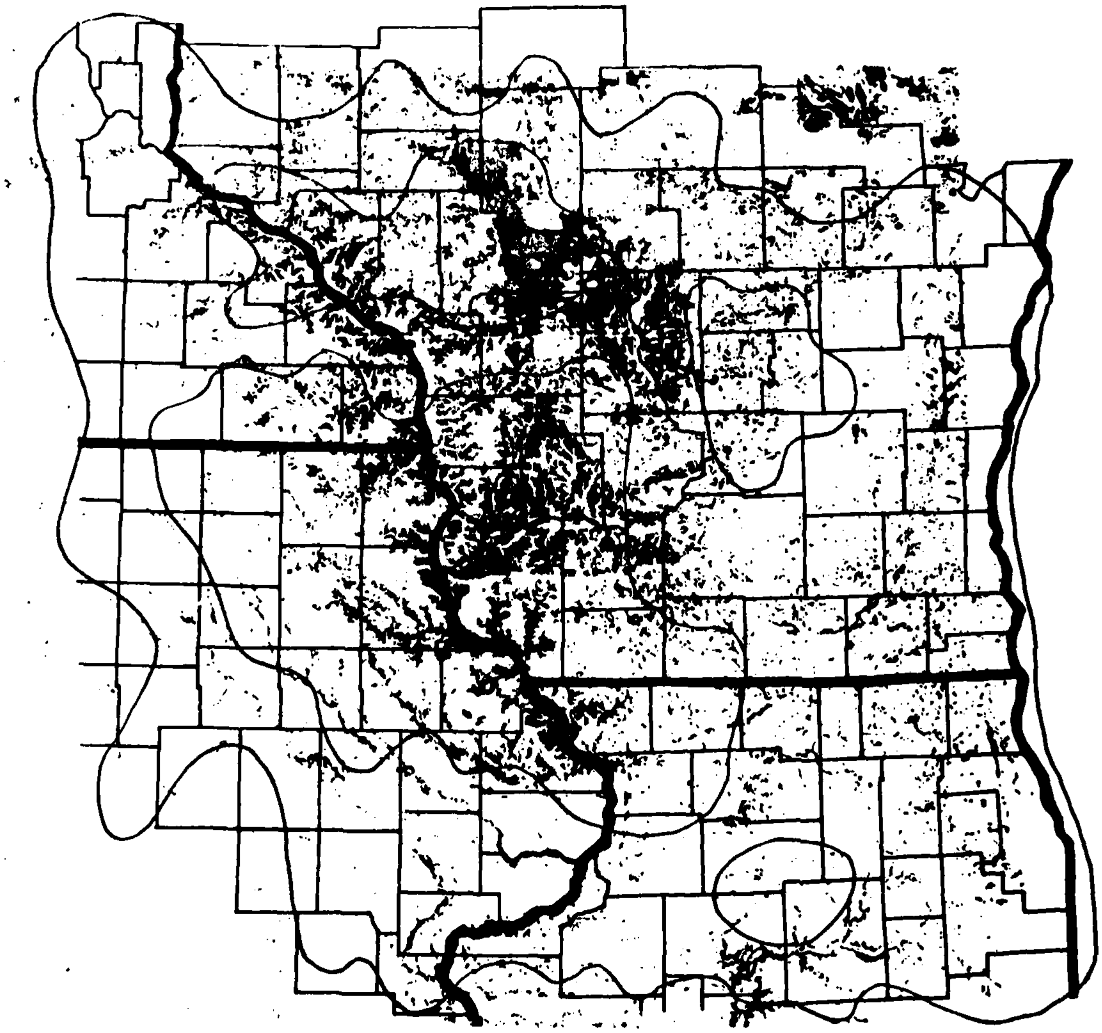


Along the rim trails, natural observation platforms protrude from which one can view the surrounding landscape — down valleys and up nooks, spreading out in a quilt-like pattern.

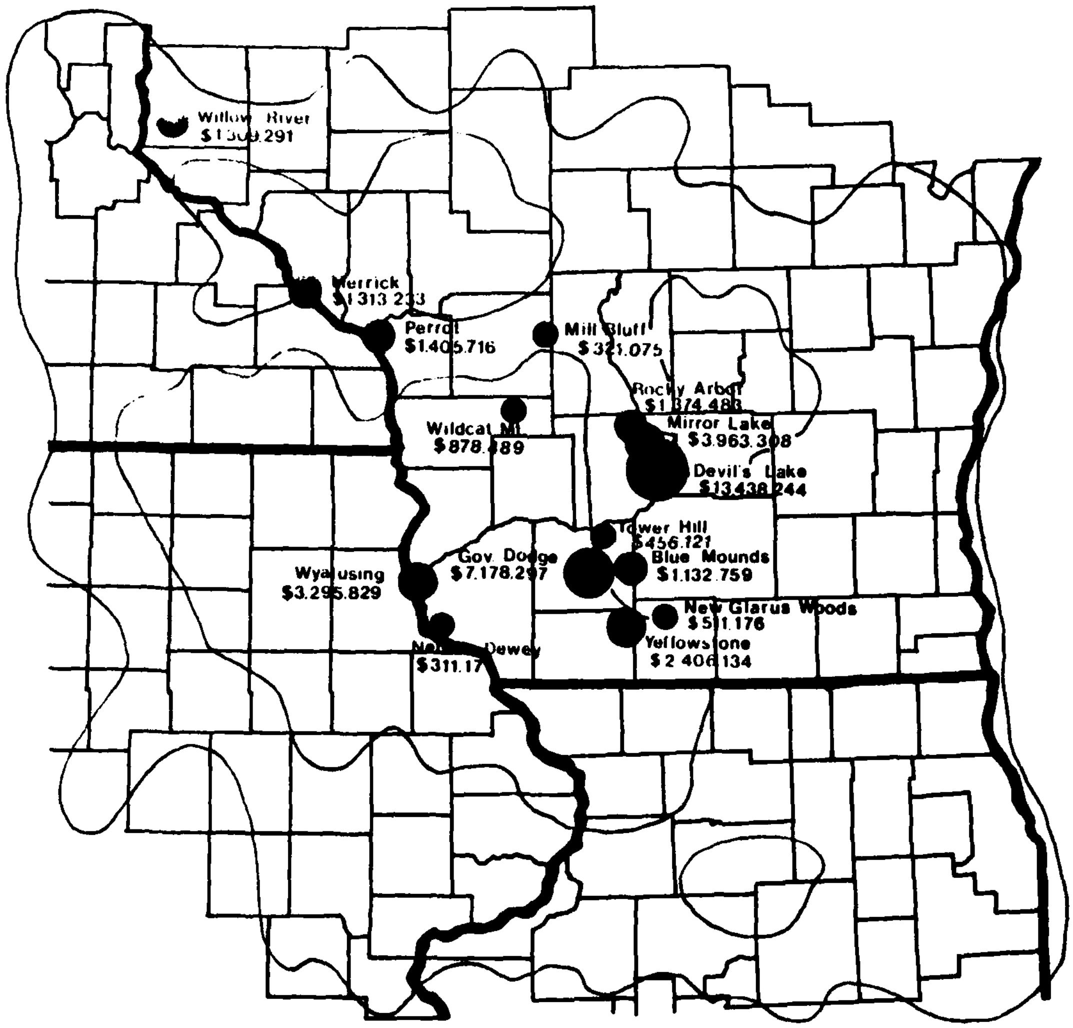


The visual extension to the far distance restores and renews man's spirit and strength in the calm and stability of the landscape and skyscape . . . a view of the rising and setting of the sun or moon.

Vegetation Cover

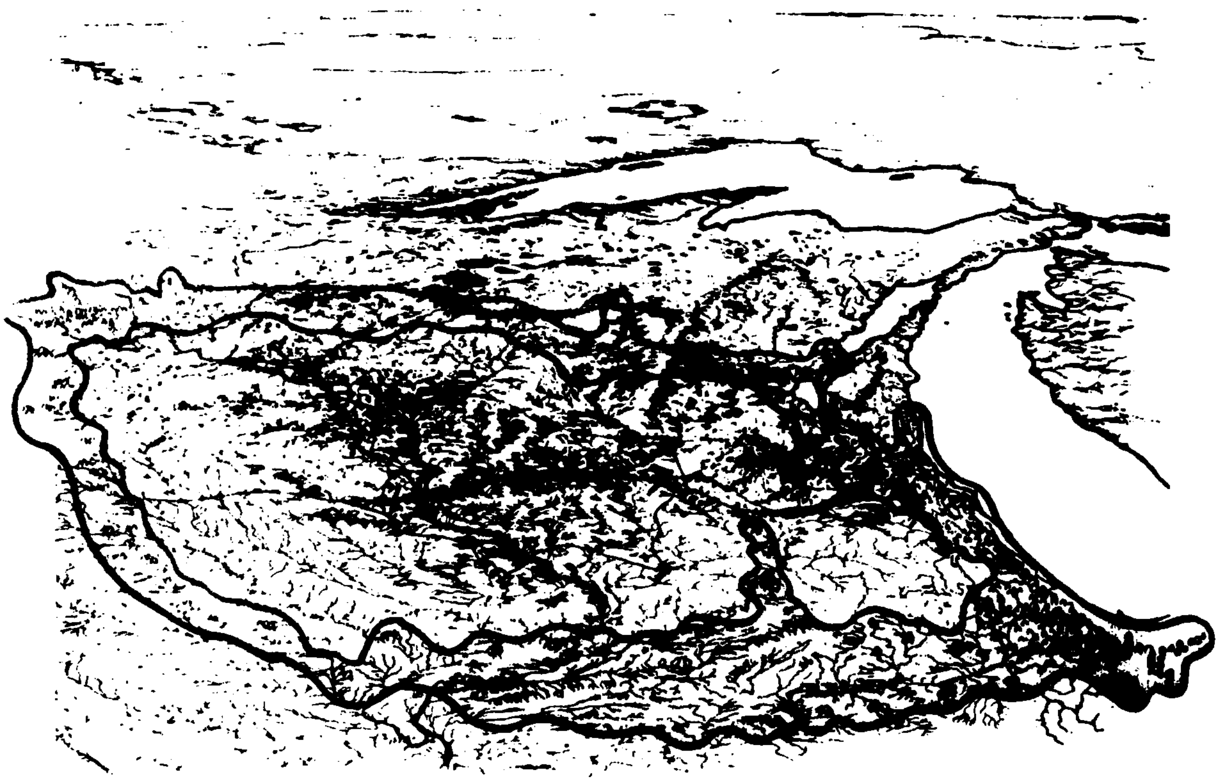


Economic Impact of State Parks in or Near the Driftless Region of Wisconsin*



*The [illegible] spent by campers in 1980

The Circle City Landscape

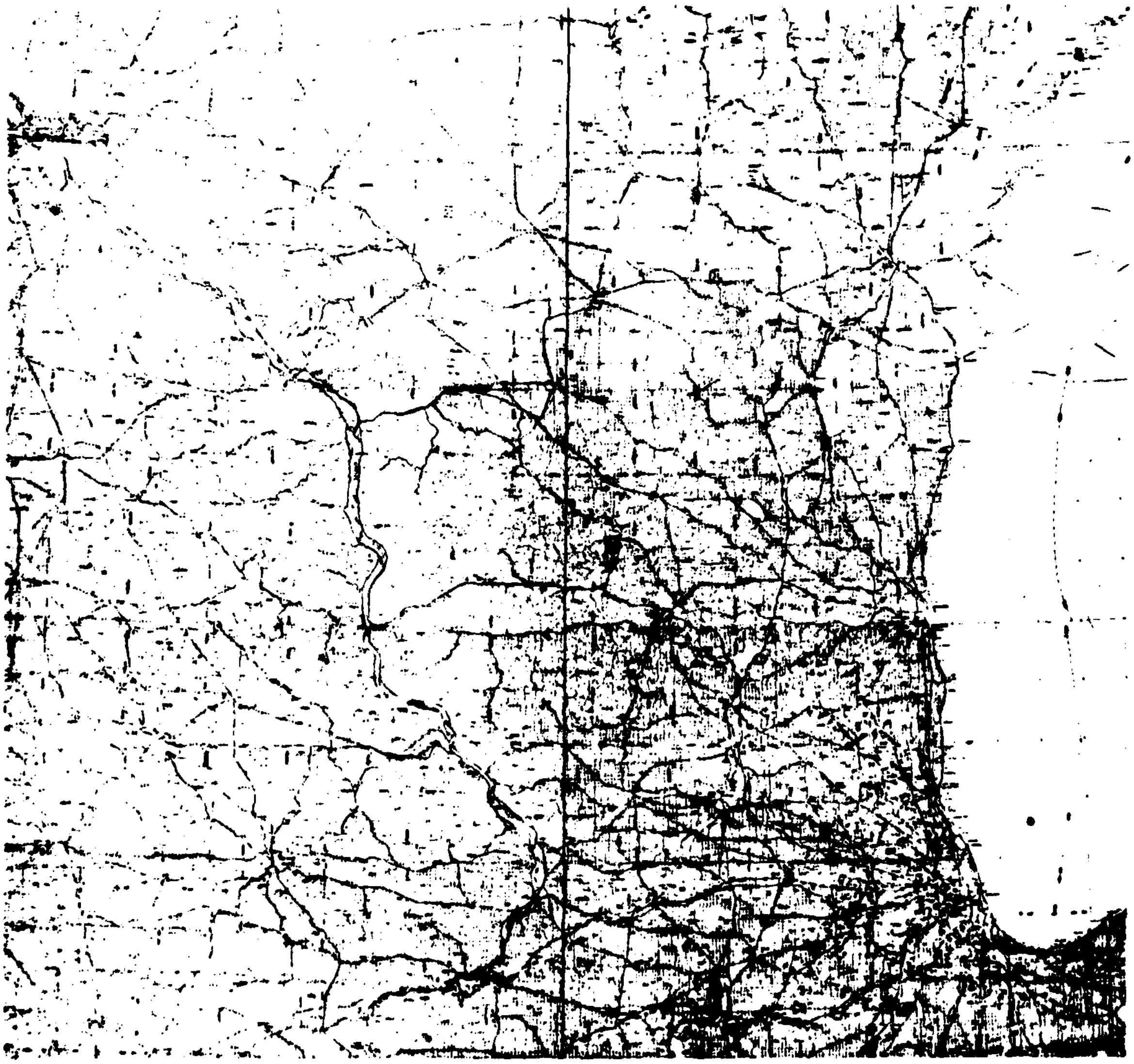


Circle City Transportation

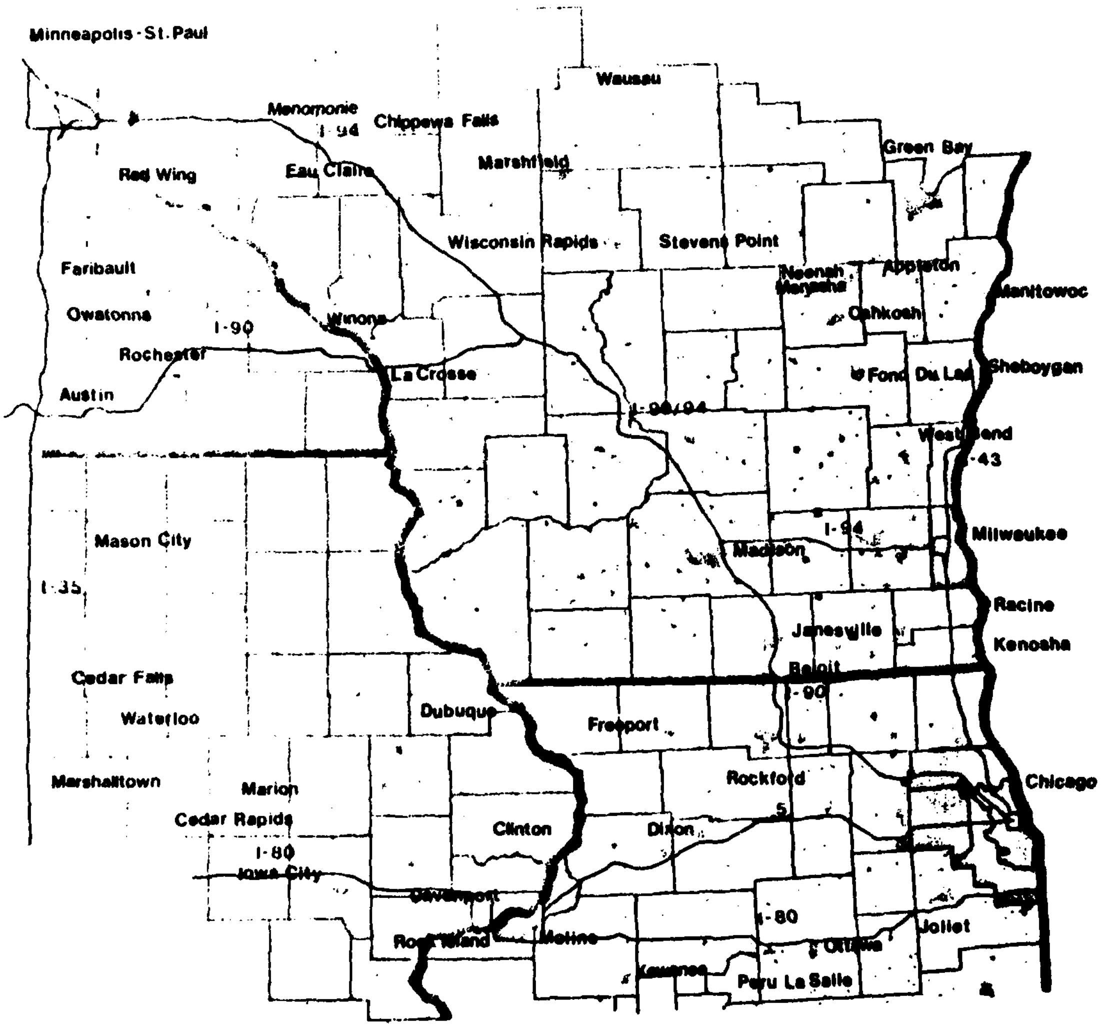
Circle City is adequately supplied with highways, rail and air transportation corridors. The network assures movement of goods and services and access to the richness of tourism attractions that generate 7 billion dollars a year.

Recognition that Circle City has a population of 17 million people is expected to generate interest in high technology mass transportation systems and integrated utilities. Such systems could well encourage creative urban infill over rail and rail yard air rights in the many cities of Circle City and the other 22 national constellations.

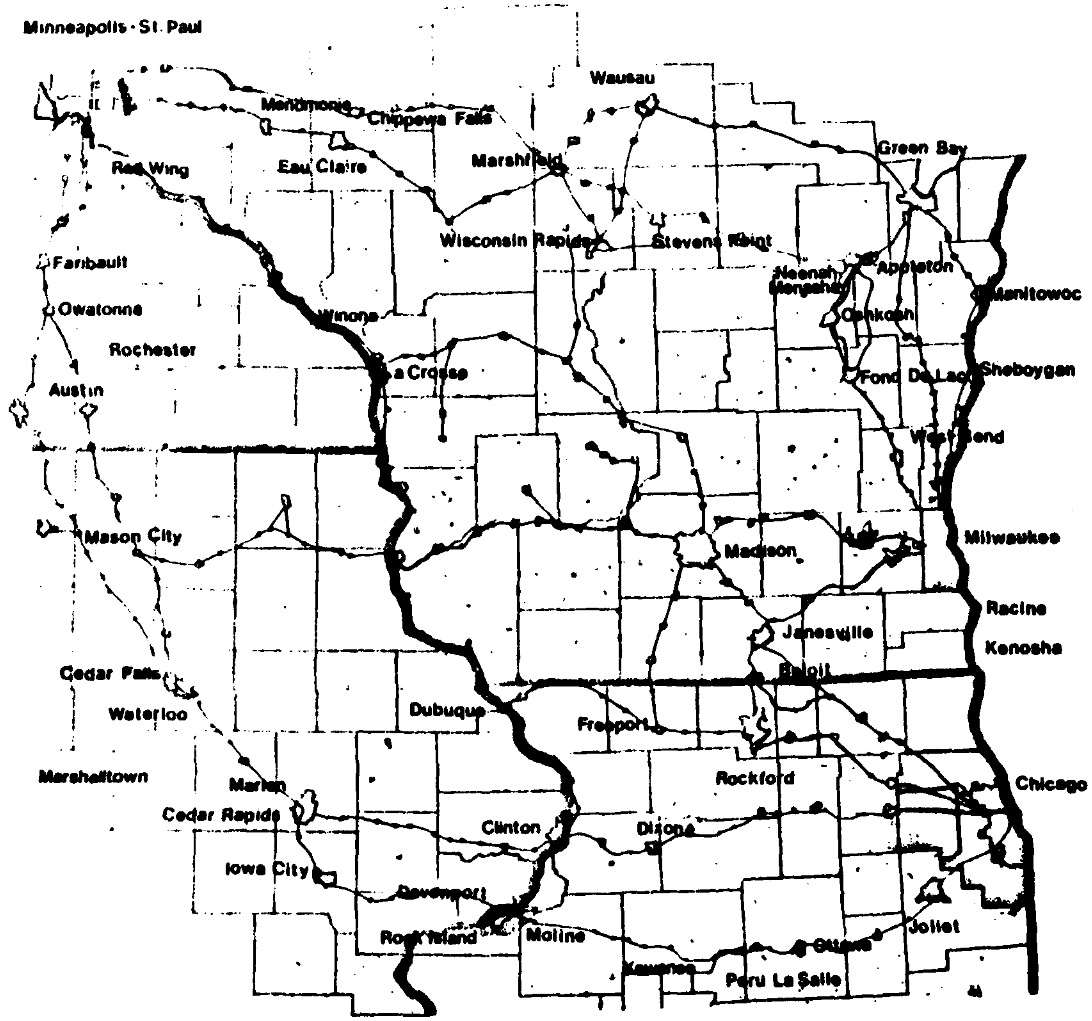
Circle City's Roads, Railroads, and Municipalities



Interstate Highways With Circle City Access



Rail Lines With Circle City Access

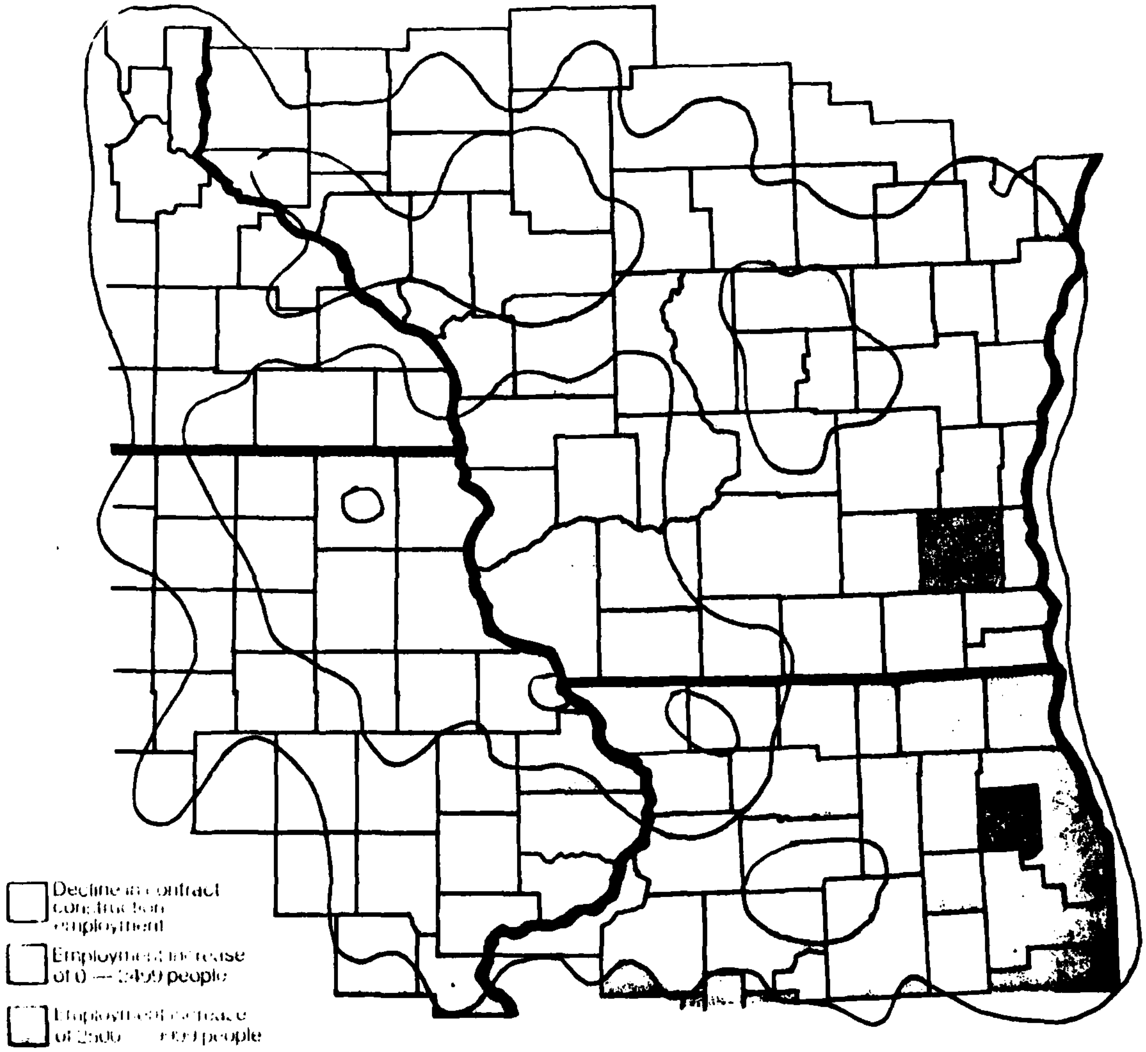


Circle City Economic Growth 1969-79

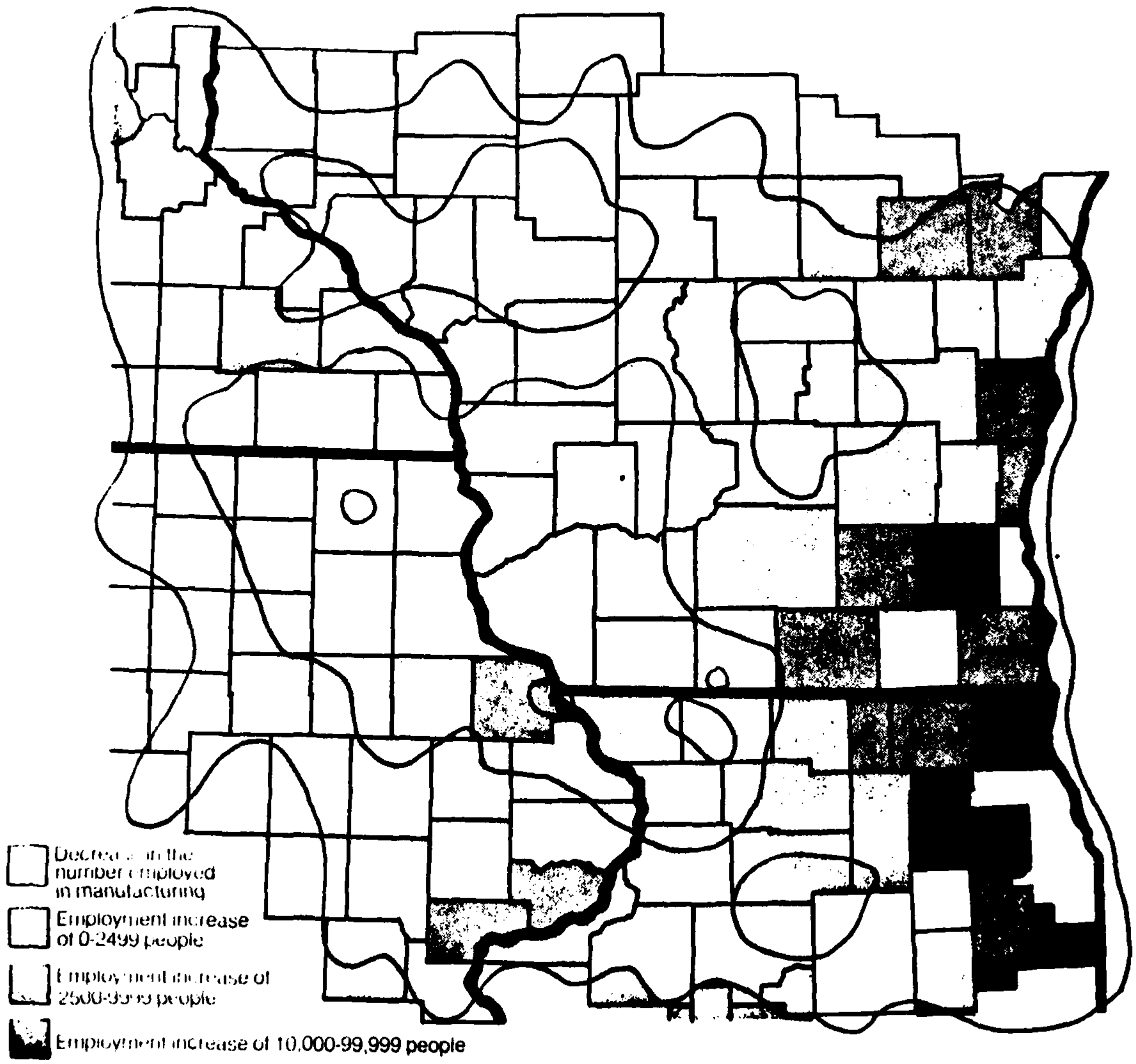
Economic growth indicators would suggest growth throughout Circle City and the inner core. This could indicate further sprawl into the hinterlands and low density development versus encouraging higher liveable densities within the existing cities of Circle City.

One scenario would be to look at creative opportunities to design higher liveable densities within the many acres of underutilized lands within most cities within our identified urban constellations. This is called urban "infill."

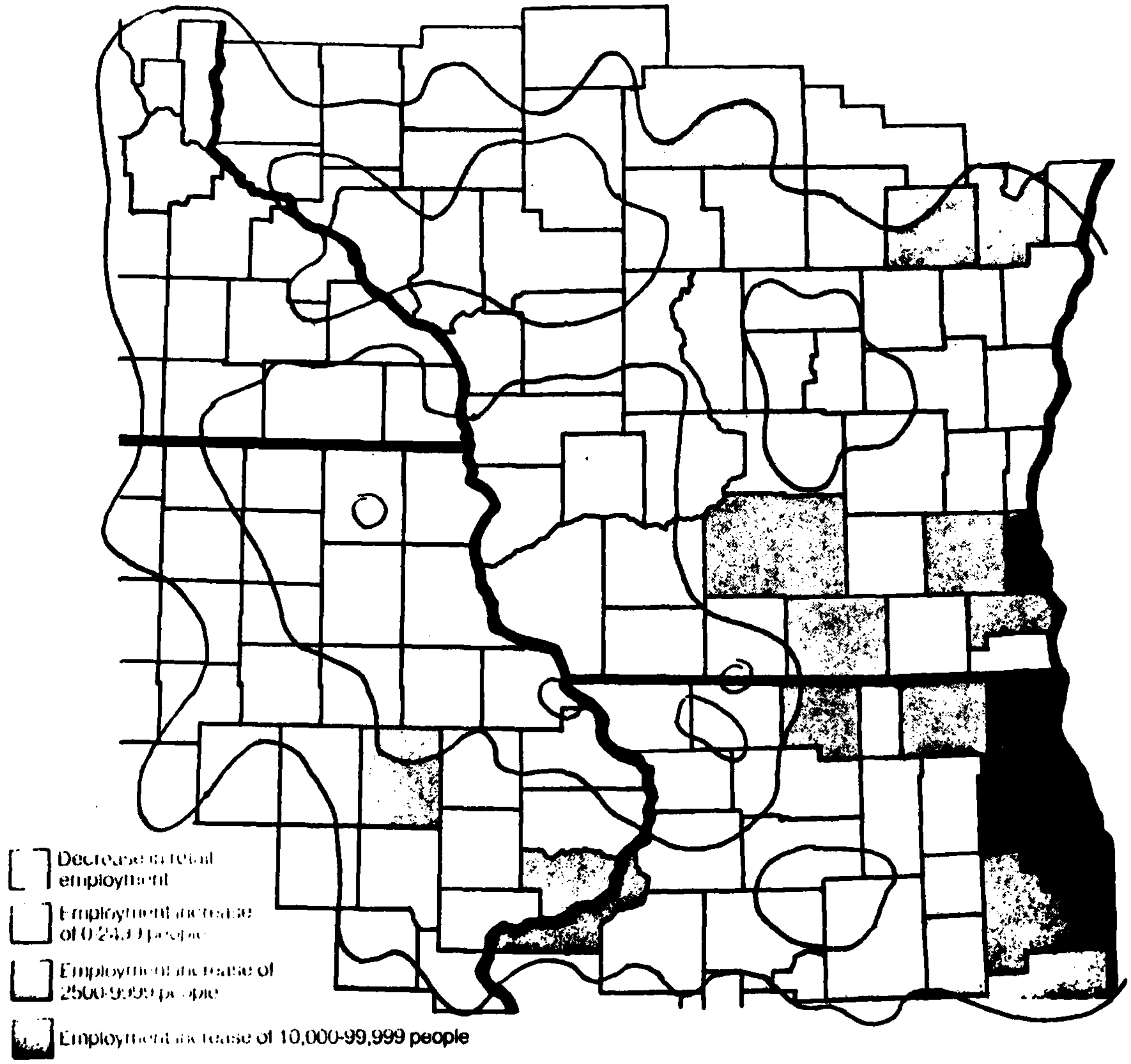
The Change in the Number of People Employed in Contract Construction (1969-1979)



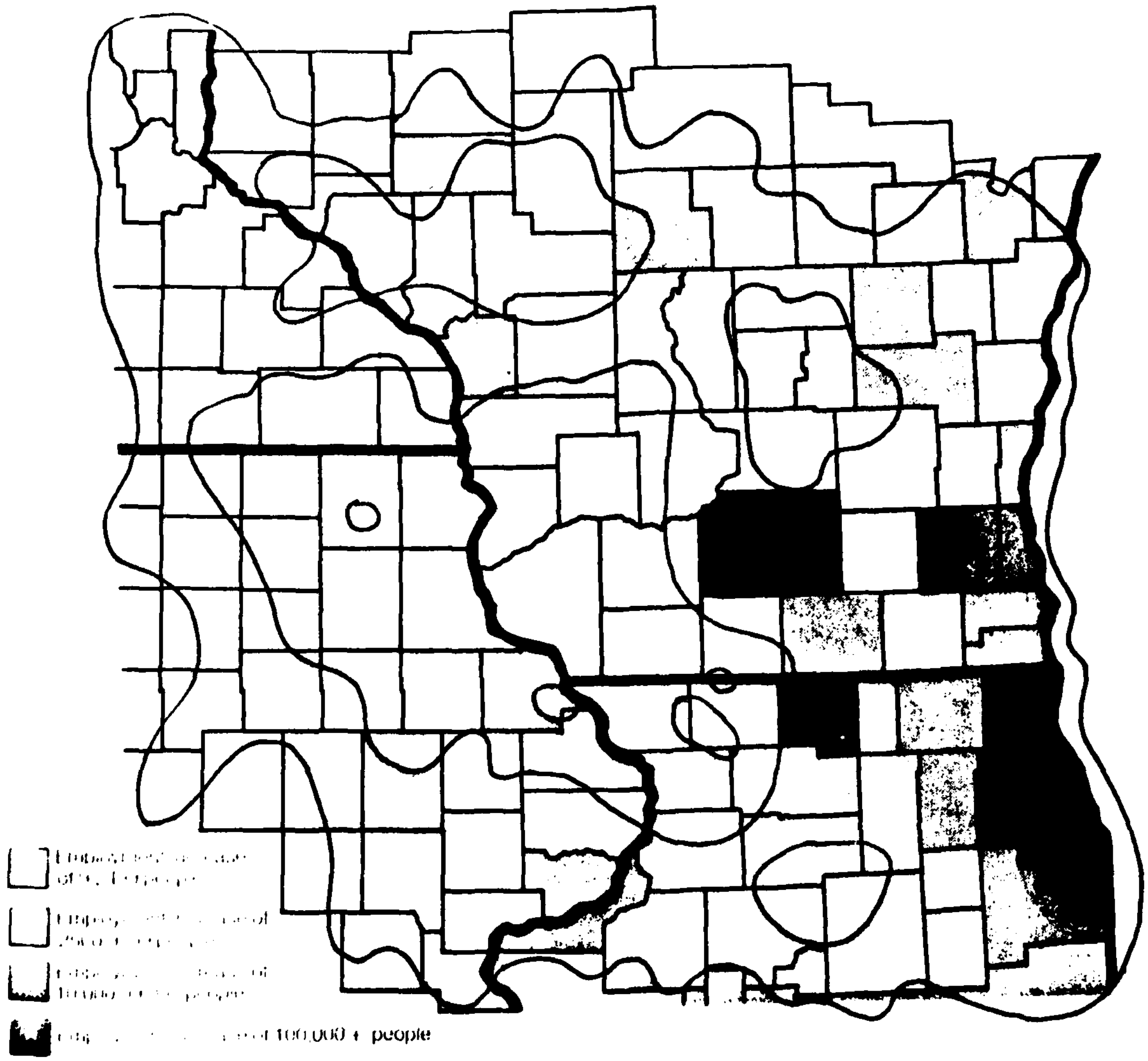
The Change in the Number of People Employed in Manufacturing Industries (1969-1979)

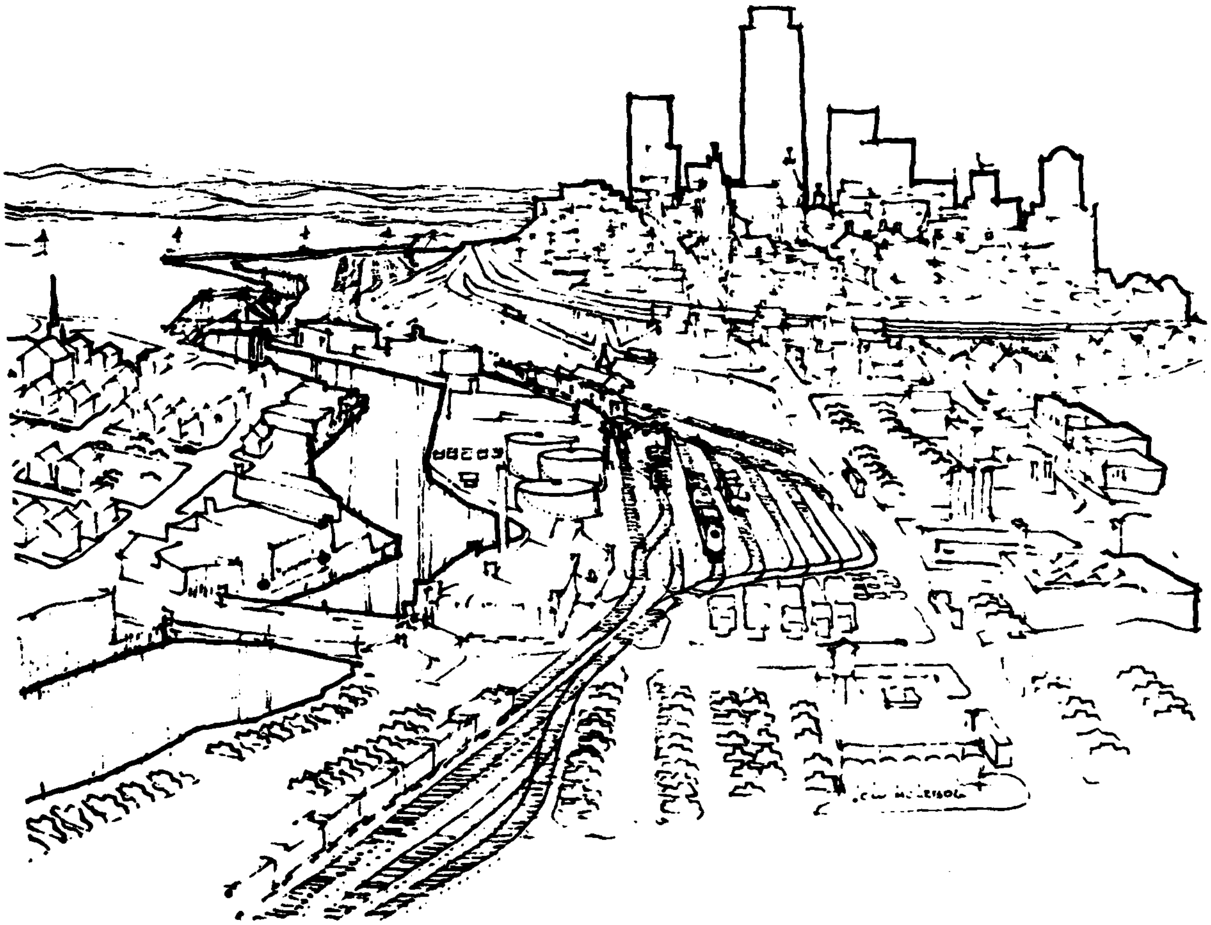


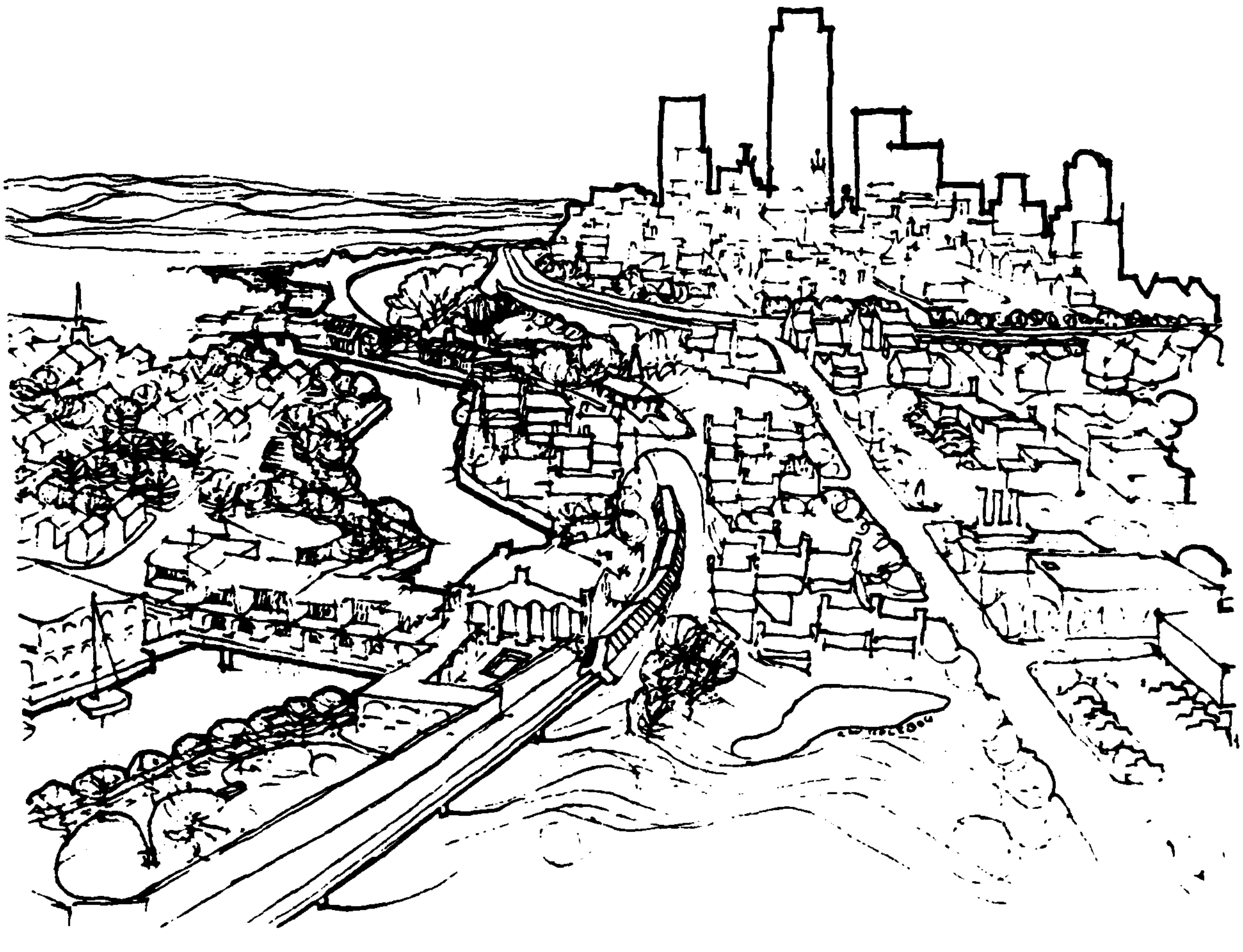
The Change in the Number of People Employed in Retail Industries (1969-1979)



The Increase [illegible] Number of People Employed in Service Industries (1969-1979)







Delayed Futurism

On the next few pages we have conceptulized possible "infill" systems, utilizing "space spanners" over rail right of ways. We term these concepts "delayed futurism" because most of the technological components of such structures are available today. Although many components of the future urban fabric are available today (new solar energy systems, new mass transit systems, new housing systems) we delay to experiment with these radically new prototypes. While our foreign friends are supporting such creativity, we wait for them through governmental subsidization to mass produce, reduce costs, and undersell us in the future. We believe the United States will be able to develop a workable private-public endeavor that will allow large-scale-liveable new concepts to be tested. We simply must!

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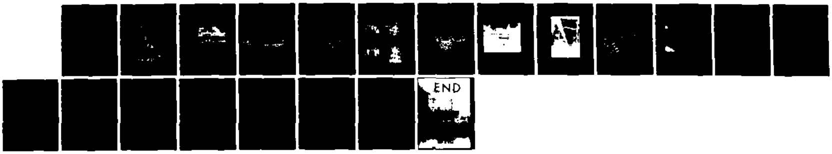
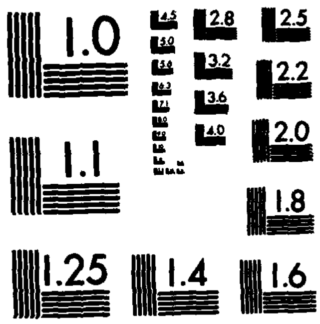
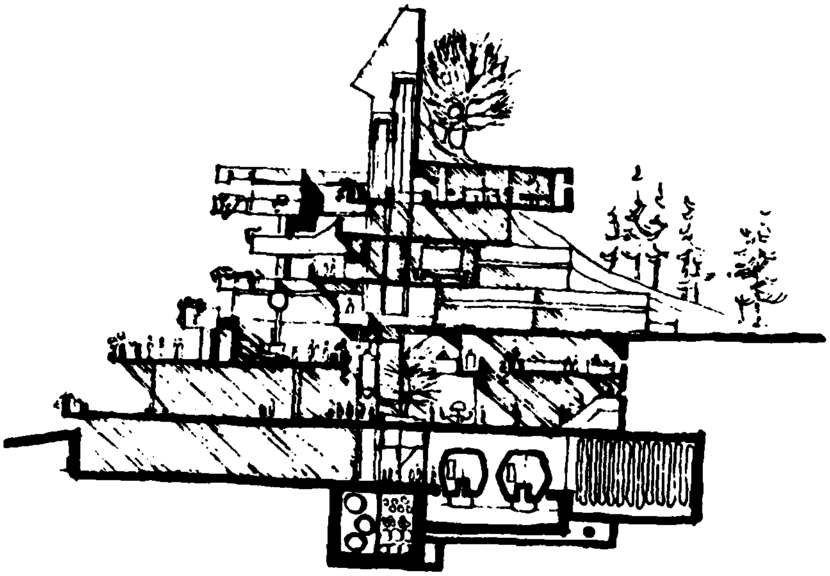
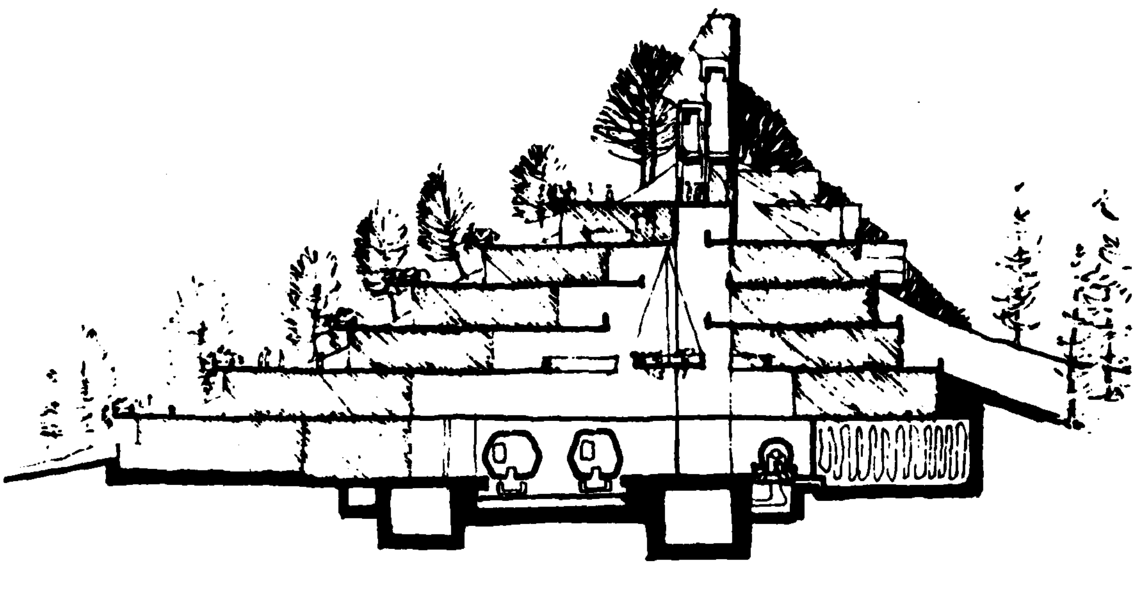
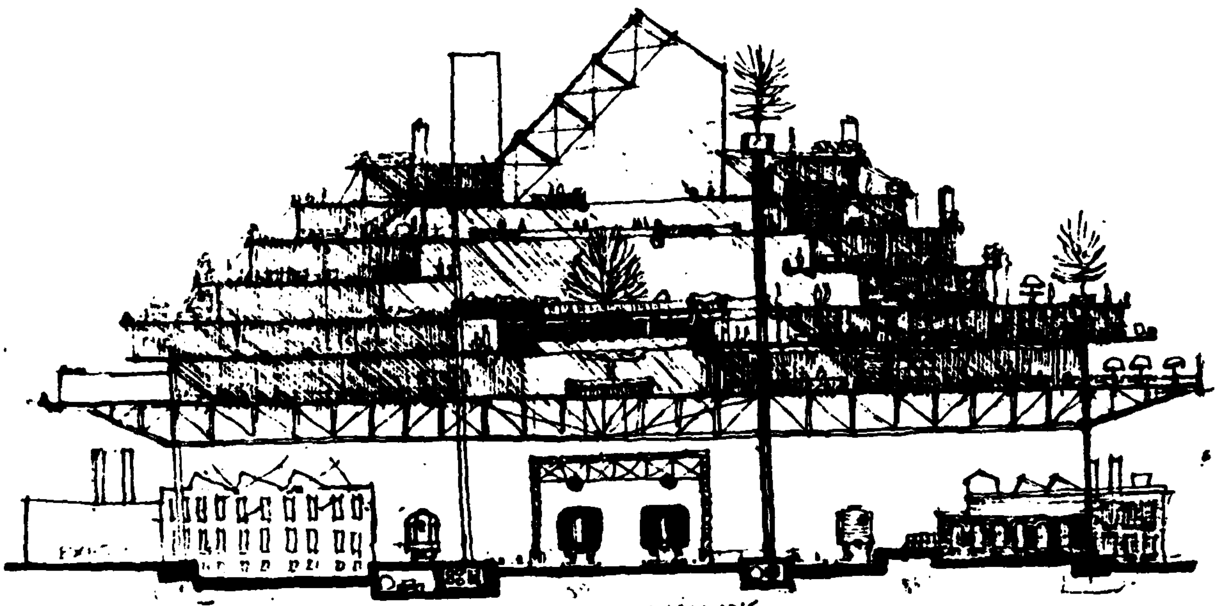


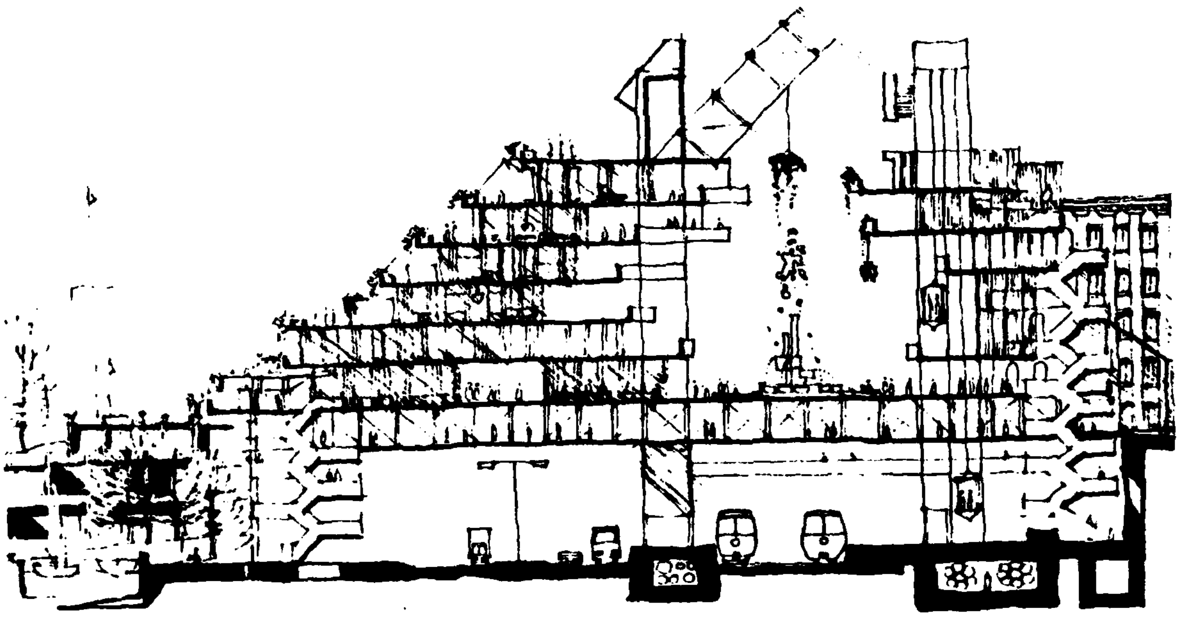


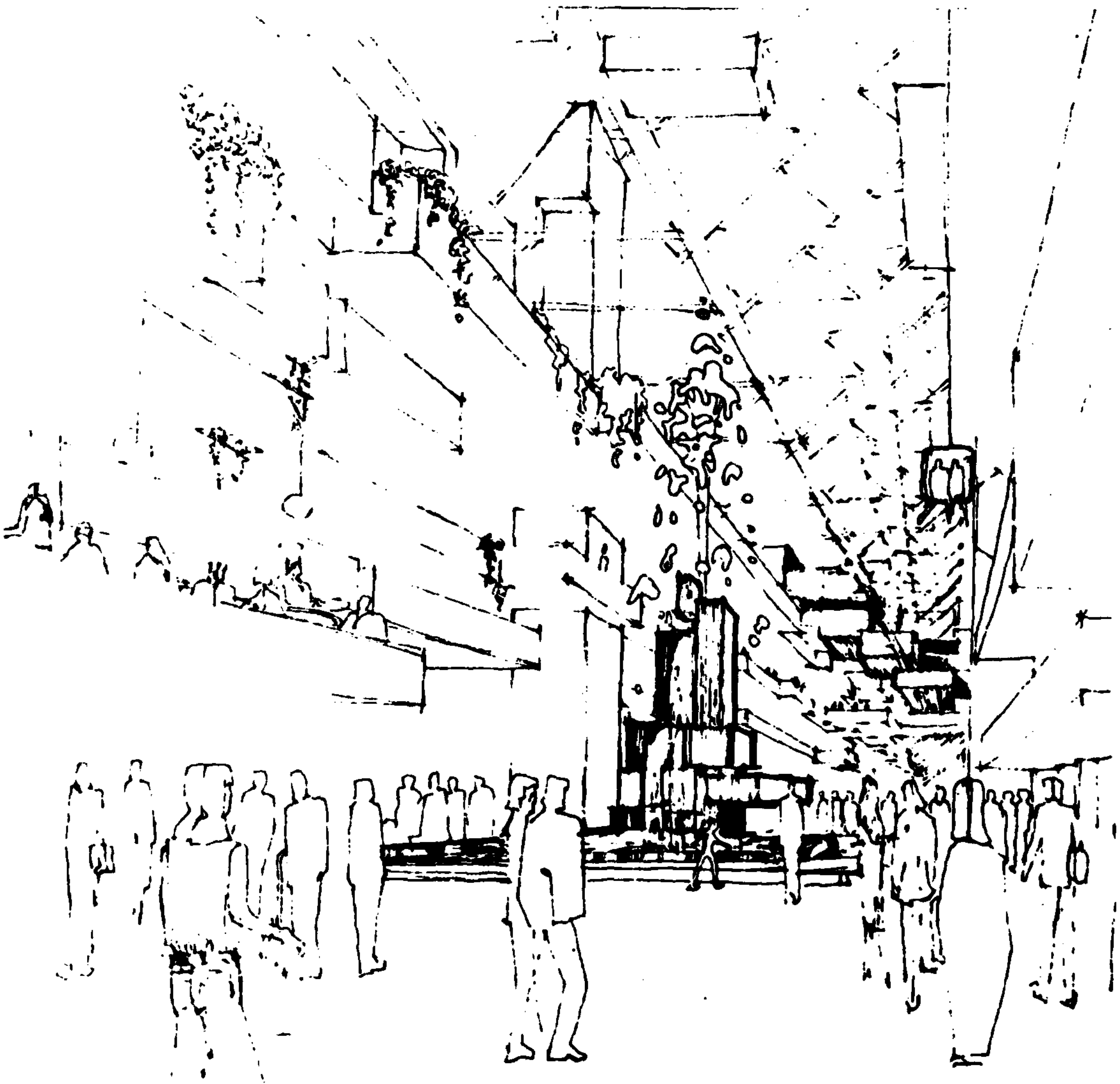
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

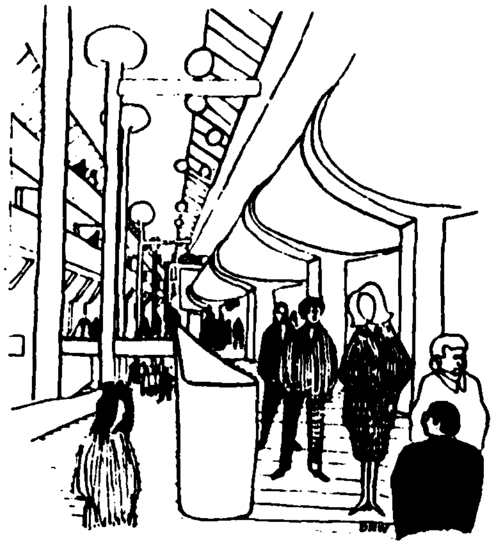


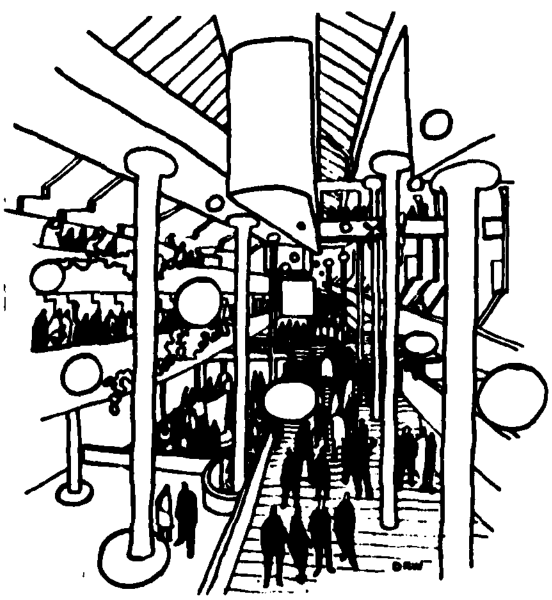


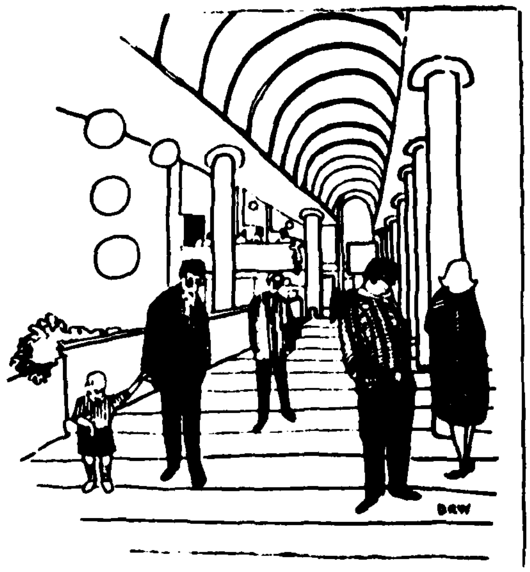


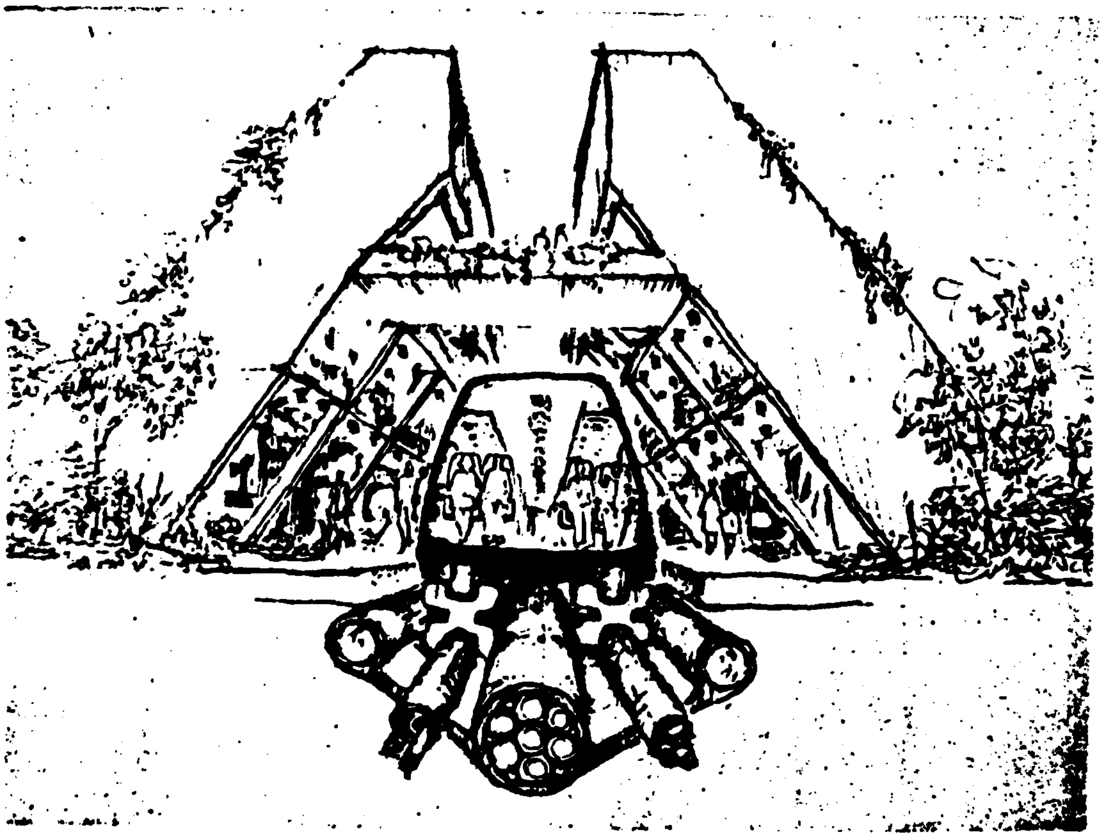










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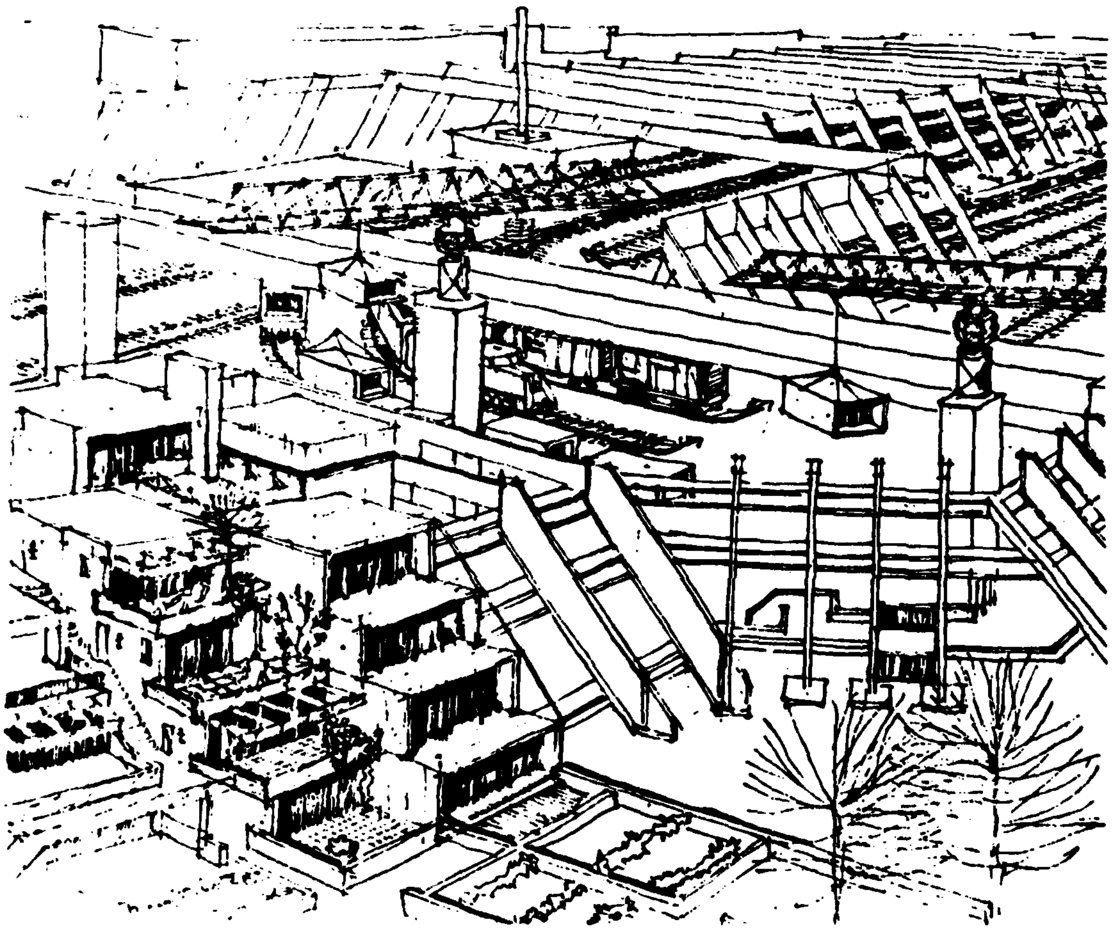

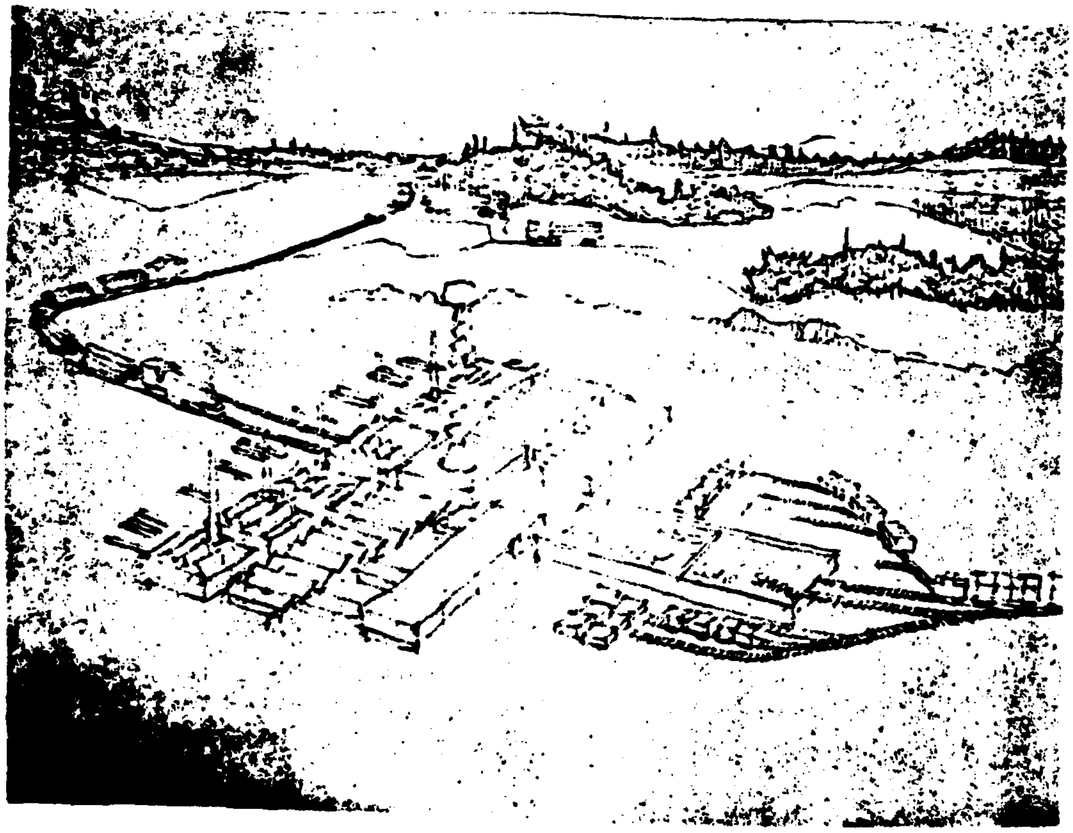

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